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35-MVA pumped-storage set in the turbine hall of Tanzmühle pumped-storage station
(Energieversorgung Ostbayern AG)

The set is started fully automatically for both generating and pumping operation. The voltage regulating and excitation system consists of a constant-voltage auxiliary generator mounted on the shaft of the main generator, a separately installed exciter set and a magnetic-amplifier voltage regulator

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Calorimetric Methods of Determining the Efficiency of Large Machines

BY WOLFGANG LIEBE AND WINFRIED BOLDIN

With a view to obtaining high efficiency, designers have always endeavoured to keep the losses of electrical machines low and keen competition has made this even more important. Reliable demonstration of the guaranteed values is therefore in the interests of both manufacturer and purchaser.

The efficiency cannot always be determined satisfactorily by conventional means; if, for example, a large water-wheel generator is only fully assembled on site, the losses of generator and turbine can no longer be properly separated. In such cases calorimetric methods are appropriate. In other cases also calorimetry can usefully be employed for testing and research on large machines.

The idea of determining the efficiency of an electrical machine calorimetrically is not new. The procedure also has long been familiar and has frequently been described in detail [1, 2, 3]. Experience of actual means of measurement and knowledge as to the accuracy attainable with large machines were, however, lacking; in particular, there were no comparative measurements of losses by calorimetric and conventional methods on one and the same machine.

Such studies have been carried out during recent years in the Dynamowerk of Siemens-Schuckertwerke. It has been found that the accuracy attainable with the calorimetric method is as good as with the usual methods. Its use, however, requires special knowledge of measurement technique and this will therefore be considered in some detail before discussing the results.

Purpose of measurement

Basically there are two possible ways of employing calorimetric methods: measurement in the air circuit, i.e. in the primary circuit of the cooling system, or measurement in the secondary water-cooling circuit (Fig. 1). The physical basis of the two methods is the same: the total losses, with the exception of a determinable remainder, are reflected as a temperature rise of the cooling medium and they can therefore be easily determined by measuring the flow of heat from the machine.

The losses measured in this way generally do not include the bearing losses, which must be measured separately. The heat dissipated from the surface of the machine casing by free convection or radiation is also not included. This can be taken into account by employing corrective factors based on empirical values, whereas the heat flowing through the machine shaft and foundations can be neglected.

The total losses P_V are thus made up of three components:

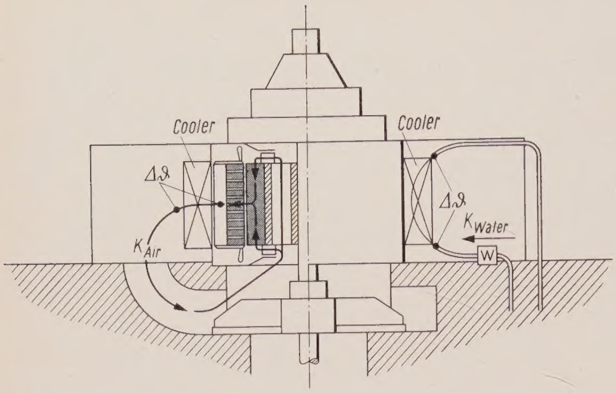
1. the heat transferred to the cooling medium, Q_K,
2. the heat dissipated by the external surface of the machine casing, Q_G, and
3. the bearing losses, Q_L:

$$P_V = Q_K + Q_G + Q_L$$

Ref. 1:

The main component of the losses transferred to the cooling medium is:

$$Q_K = K\, \Delta\vartheta\, c\, \varrho$$



Total losses $P_V = K\,\Delta\vartheta\, c\,\varrho + Q_{\text{casing}} + Q_{\text{bearings}}$

Fig. 1 Cooling system of a waterwheel generator with closed-circuit cooling and principle of calorimetric test, left in the air circuit, right in the water circuit. Volumetric flow K and temperature rise $\Delta\vartheta$ of cooling medium are measured

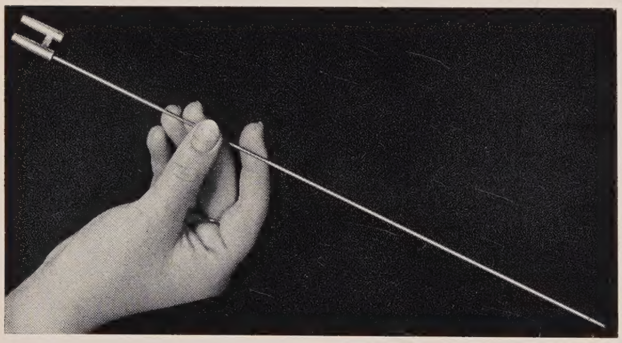


Fig. 2 Special flow-sensing element for measuring the pressure drop across the cooler. The pressure difference is picked off at two nipples

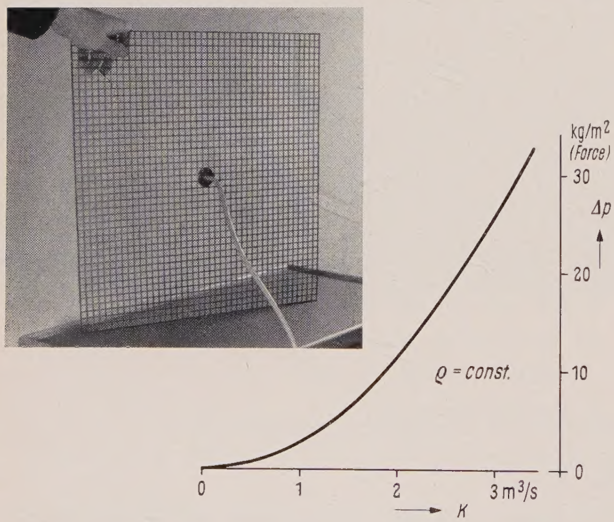


Fig. 3 Screen for determining the air flow rate from the pressure drop

To determine the electrical and mechanical losses included in this heat flow it is accordingly only necessary to measure the flow of the cooling medium K in m³/s and to determine its temperature rise $\Delta\vartheta$ in °C. The specific heat c of the cooling medium in W-s/kg-°C as well as its density ϱ in kg/m³ at the point of measurement must also be known.

Ref. 2:

The heat dissipated from the machine housing can be estimated if the mean temperature of the casing ϑ_G and the mean ambient temperature ϑ_0, also the effective heat-transfer surface A of the casing and the heat transfer coefficient α are known:

$$Q_G = \alpha A\,(\vartheta_G - \vartheta_0)$$

Experience shows that for large machines the heat transfer coefficient can be taken as about 10 W/m²-°C*.

Ref. 3:

The losses of fluid-cooled bearings can be determined calorimetrically, account being taken in this case also of the heat dissipated by radiation and convection.

With P_V as the sum of the three components Q_K, Q_G and Q_L, the efficiency can now be calculated as below, P being the power output of the machine:

$$\eta = 1 - \frac{P_V}{P + P_V}$$

The determination of the efficiency thus depends essentially on measurements of volumetric flow and a measurement of temperature. This applies both to the air circuit and to the water circuit.

Method of measurement

Primary circuit

For an accurate measurement of flow the cooling medium must be passed through a definite cross-section, which it fills completely. The coolers themselves may be used as a measuring device, as there is a definite relationship between the pressure drop in the fin-tube banks and the flow. To derive the flow rate from the pressure difference obtained from the cooler characteristic it is then only necessary to measure the pressure before and after the cooler. Fig. 2 shows a special measuring device for this purpose: it is a flow-sensing element in the form of a hollow steel needle, which can be pushed through the fin-tube banks and supplies the difference between the pressures at two nipples. Highly sensitive pressure gauges, e.g. inclined manometers are used for the measurement.

The "cooler-pressure-drop method" was developed on this principle, with the aid of which the first successful

* American specifications give 7.75 W/m²-°C, whereas the Swiss Association of Electrical Engineers suggests 10 to 20 W/m²-°C.

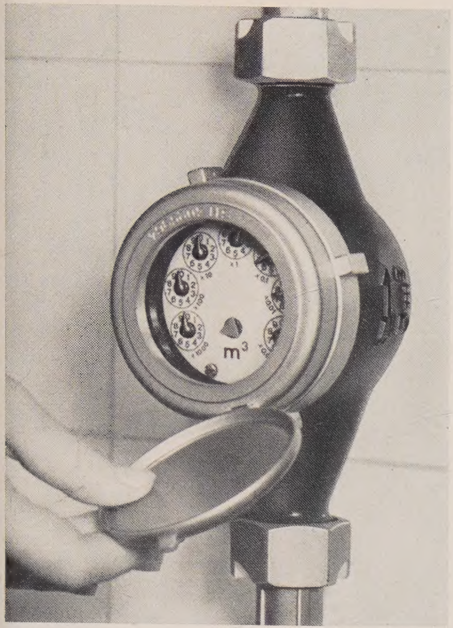


Fig. 4 Vane-type water meter

calorimetric tests on large machines were carried out (see Fig. 5) The use of this method presupposes accurate knowledge of the cooler characteristic, i.e. the relationship between pressure and rate of flow.

Conditions are more difficult in open-circuit ventilation when fresh air is forced through the machine and there is no cooler in the circuit. Measurement in the air circuit is then the only possible calorimetric method, since there is only the primary cooling circuit. For this case simple, calibrated orifices in the form of wire-mesh screens have proved to be useful (Fig. 3). Depending on the flow, several such orifices can be placed side by side, like resistors connected in parallel.

The temperature measurement in the air flow usually presents no difficulty. The temperature difference in segregated loss measurements is of the order of 10 °C and can be measured with sufficient accuracy with a mercury thermometer graduated in tenths of a degree. If there are coolers in the air circuit and the temperature difference across the cooler is to be determined, the air temperature at the outlet side of the cooler should be measured at several points, because the degree of cooling of the air may differ at different places owing to the heating up of the water. The pressure difference must also be measured at several points if the velocity of flow is not everywhere the same. It will accordingly often be necessary to gauge the whole cooler section.

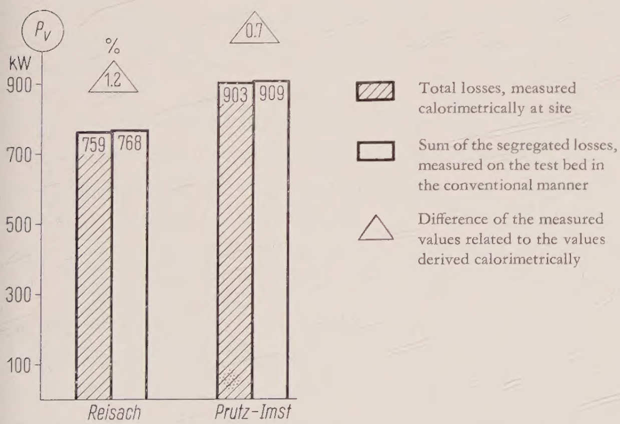


Fig. 5 Results of the first calorimetric loss test on large waterwheel generators, in the air circuit by the cooler-pressure-drop method

Secondary circuit

A calorimetric measurement in the water circuit can always be carried out if the cooling medium is circulated in a dosed circuit and passed through water coolers. The cooling-water flow is measured by means of ordinary commercial vane-type water meters (Fig. 4). These permit very accurate measurement but it must be ensured that no air or gas is mixed with the water. Means of connecting these meters into the pipework are provided initially.

The temperature difference in the water between the hot and cold flow can be measured electrically by means of platinum resistance thermometers. The detecting elements are directly exposed to the cooling-water flow.

The heat flow, which the cooling water carries with it, comprises not only the machine losses but also the pressure losses in the cooler, i.e. the head lost in forcing the water through the cooling tubes. These losses are small and, if the pressure drop in the cooler is known, can be calculated from the product of the pressure drop and the cooling-water flow.

Accuracy of calorimetric tests

To check the accuracy of calorimetric methods tests were carried out on a model cooling circuit, in which the electrical heating power fed in could be accurately determined. These tests showed that the air-calorimetric measurement differed from the electrical measurement by not more than ±3% and the water-calorimetric measurement, assuming gas-free water flow, by not more than ±1%.

It can be assumed that with care the same degree of accuracy will be attained on the machine. The following comparison between the calorimetric and the conventional methods of testing waterwheel generators shows that the deviations are very small, provided that they are not influenced by differences in the set-up or other errors. Accordingly, assuming a machine efficiency of 97%, at the worst the uncertainty in the efficiency determination by the calorimetric method is $\pm 0.03 \times 0.03 = \pm 0.001$ or $\pm 0.1\%$.

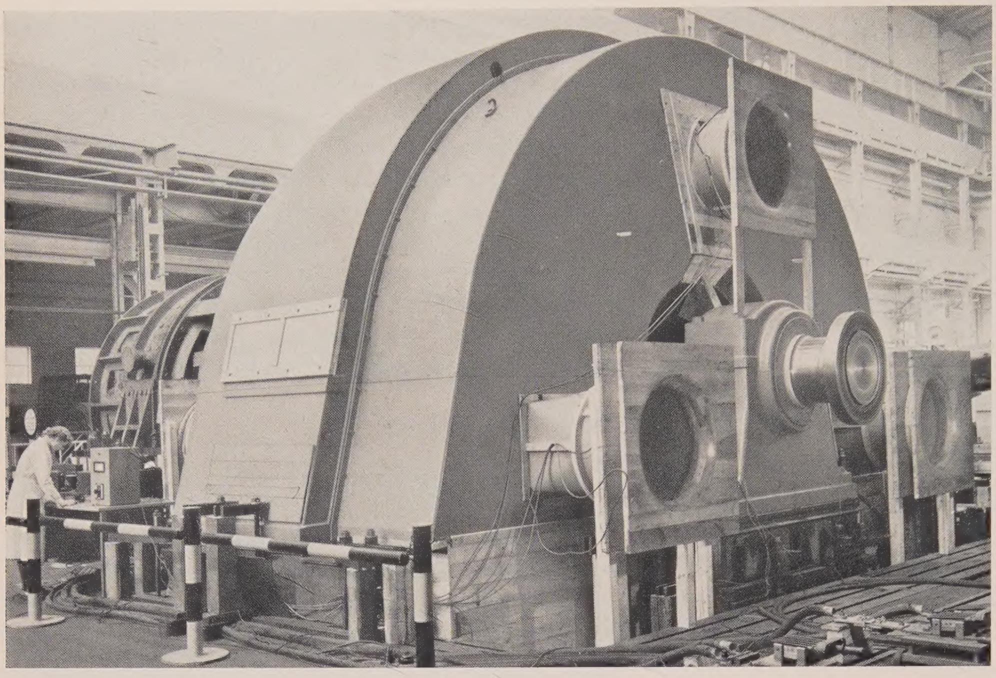


Fig. 6 Three-phase synchronous generator for the Reisach, West-Germany, pumped-storage station on the test bed

Results

During the last few years fifteen waterwheel generators have been tested by calorimetric methods, five in the air circuit and the rest in the water circuit. By reason of the good results obtained, the calorimetric method can be confidently recommended for the measurement of losses dan determination of the efficiency of water wheel generators.

In the case of seven machines it was possible to compare the results of the calorimetric test with those obtained on the test bed or with retardation tests carried out on site. These cases are discussed in detail below.

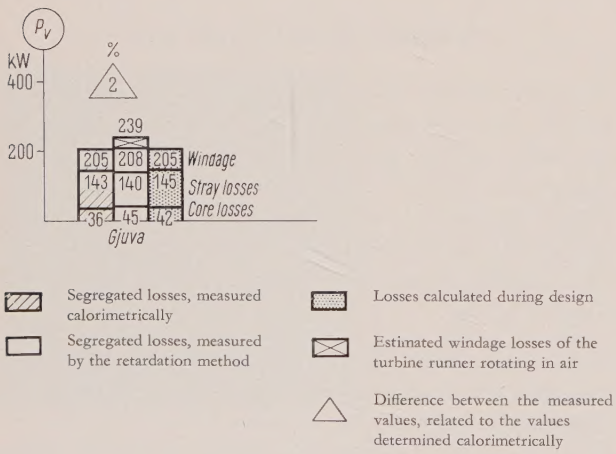


Fig. 7 Results of comparative tests in the Gjuva hydro-electric station. The calorimetric test was carried out in the air circuit with the aid of screens (see Fig. 3). The windage losses determined by the retardation method are too high because of the losses of the turbine runner rotating in air. If the estimated value for this is subtracted, the retardation and calorimetric measurements are in close agreement

Fig. 5 shows the full-load losses measured calorimetrically at site on waterwheel generators in Reisach, West-Germany, and Prutz-Imst, Austria, power stations. Also shown are the losses determined on the same generators in the factory by the conventional method of measuring losses with a calibrated driving motor. The results of the calorimetric tests, carried out in both cases in the air circuit, agree closely with the test-bed measurements, although total losses are compared with the sum of the segregated losses. The differences are only 1.2 and 0.7% respectively. It should be mentioned that in both cases particular care was taken to adapt the ventilating conditions on the test bed (Fig. 6) to those on site so as to obtain the same windage losses.

Fig. 7 shows the results of an investigation on a comparatively smaller generator (Gjuva hydro-electric station). In this case not the total losses but the segregated losses (windage, stray and core losses) were determined in the usual manner. These losses have been compared with the corresponding segregated losses determined by retardation tests at site; these are shown side by side with the estimated design losses.

It will be seen that the segregated losses measured calorimetrically differ very little from the calculated values. On the other hand, the loss figures obtained by the retardation method are considerably higher than those derived from the calorimetric test. The difference lies mainly in the windage losses and in this case is undoubtedly attributable to the turbine, since with the retarda-

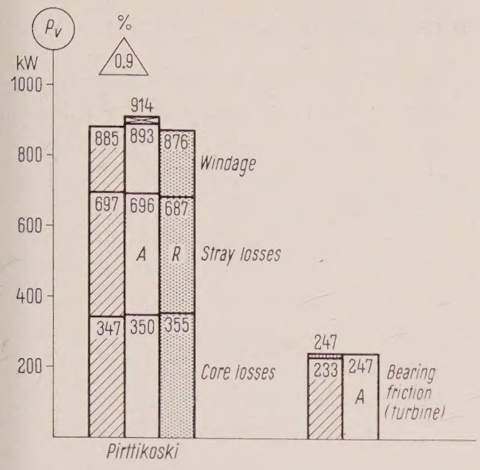


Fig. 8 Segregated losses of a generator in the Pirttikoski power station. If the calculated windage losses of the turbine runner are subtracted, the results agree closely (for explanation see Fig. 7)
Right: The bearing losses of the turbine determined by the retardation method agree very closely with the values measured by water-calorimetry in the cooling-water circuit of the thrust bearing, if allowance is made for the gland and guide bearing

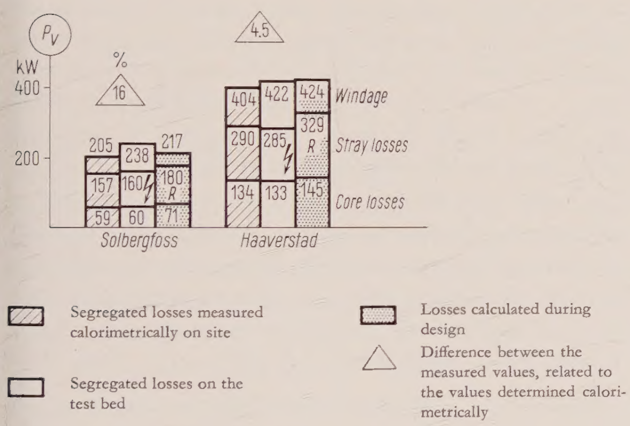


Fig. 9 Test results and calculated values for the generator losses in the Solbergfoss and Haaverstad power stations. The measured stray and core losses are in close agreement. Only the windage losses as determined on the test bed are too high because the lower covering is absent

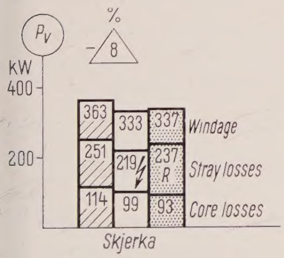


Fig. 10 Measurements on the generator for the Skjerka hydroelectric station. The losses determined by water-calorimetry are too high because air had been drawn into the cooling-water circuit (for explanation see Fig. 9)

tion method the measured value includes not only the friction losses of the generator but also the losses of the turbine runner rotating in air.

Fig. 8 shows a similar case (generator for the Pirttikoski power station), in which the results of the calorimetric test carried out in the water circuit are compared with those of the retardation method and also with the preliminarily estimated values.

In Fig. 9 the results obtained by calorimetric tests in the water circuit of two generators (Solbergfoss and Haaverstad power stations in Sweden) are compared with test-bed measurements. Whereas the core and stray losses are in close agreement, the windage losses as measured on the test bed are considerably higher. This is due to the provisional assembly on the test bed, as the usual bottom cover provided by the concrete foundation on site is here absent. For this reason the conventional factory tests on a vertical generator often give too unfavourable results.

On the other hand, tests at the Skjerka, Norway, power station (Fig. 10) showed a quite different picture. For the three segregated losses the calorimetric test gave considerably higher figures than the conventional test on the test bed. It was later found that the water pump which supplied the cooling-water system was sucking in air, so that the volumetric meter was not completely filled with water but partly with air. This falsification of the test results by gas occlusion is a cause of uncertainty in the use of the water-calorimetric method. It can be avoided if the cooling water flow is carefully monitored for freedom from gas.

Segregated losses

The calorimetric method may be used both for measuring segregated losses and the total losses. In some cases it has been possible to determine both. It was found that the total losses differed by not more than 3% from the sum of the segregated losses. This difference is insignificant and is within the accuracy of measurement. As, on the other hand, the measurement of the segregated losses gives a deeper insight into their relationships and further it may be difficult to keep the full-load conditions constant for the minimum period of six hours, which is necessary for a total-loss test, the segregated-loss method is preferable to the total-loss test.

Bibliography

[1] Richter, R.: Elektrische Maschinen Bd. II, Abschnitt II K. Springer-Verlag, Berlin-Göttingen-Heidelberg. 2. Auflage 1953

[2] American Institute of Electrical Engineers: Test Code for Synchronous Machines, No. 503, June 1945 pp. 21 to 24

[3] Regeln für elektrische Maschinen. Bull. Schweiz. Elektrotechn. Ver. **41** (1950) pp. 859 to 880

[4] Aemmer, F.: Über die Bestimmung der Verluste von elektrischen Generatoren nach der kalorimetrischen Methode. Bull. Schweiz. Elektrotechn. Ver. **50** (1950) pp. 1165 to 1170

[5] Bitter, K.: Die Wirkungsgradmessung nach dem Kalorimeter-Verfahren und die Anwendung desselben bei den Generatoren des Kraftwerks Ybbs-Persenbeug. Elin-Zeitschrift **12** (1960) pp. 71 to 80

Fifty Years of Siemens Amplifier Technology

By Heinrich Nottebrock †

Originally intended for long-range telephony, the amplifier tube, which may be described as an inertialess and practically inputless energizable relay, has won a progressively expanding range of application. Circuits operating with amplifiers are today widely used, for instance, in many other branches of engineering such as medical electronics and instrumentation. Many modern technical achievements such as radio broadcasting, sound and color films, television, etc., may be said in fact to owe their development and growth to the amplifier tube.
Senior Engineer H. Nottebrock, who was an active worker in the development of the telephone amplifier ever since the early beginnings of amplifier technology, here gives a brief account of its development.

In the 1870's, when it for the first time became possible to telephone from one place to another with the aid of a telephone microphone and telephone receiver, and when it subsequently became possible to replace open-wire lines by cable lines which were more dependable but whose attenuation was considerably higher, an increasingly urgent demand developed for a device which, in a manner analogous to the telegraph relay, could be used to amplify electrical speech powers. Although it had by then become possible to extend the range of a telephone line considerably by increasing its inductance (Heaviside 1893, Pupin 1899) and using conductors with a diameter of 2 and 3 mm (Rhineland cable, begun 1912, completed 1921), long-distance operation of the type known to telegraphy was still not yet attained.

However remarkable these developments, and especially that of the Pupin loading coil, may have been from the respective standpoints of engineering and economy, none could properly be regarded as an amplifier because they could not be used to control locally fed energy.

A review of the early efforts of some 50 years ago to devise an amplifier technique, and of the types of amplifier developed over this period, may well today make interesting reading, the more so as very few who were privileged to observe or take part in this phase of engineering history are still alive. At the same time an account will be given of the decisive contributions to amplifier technology made by Siemens & Halske.

The problem in those days was not merely to devise an active component but to develop at the same time amplifier circuits that could readily be inserted in telephone lines. Today the amplifier is used for an extremely wide range of application not only in communications engineering but in engineering in general.

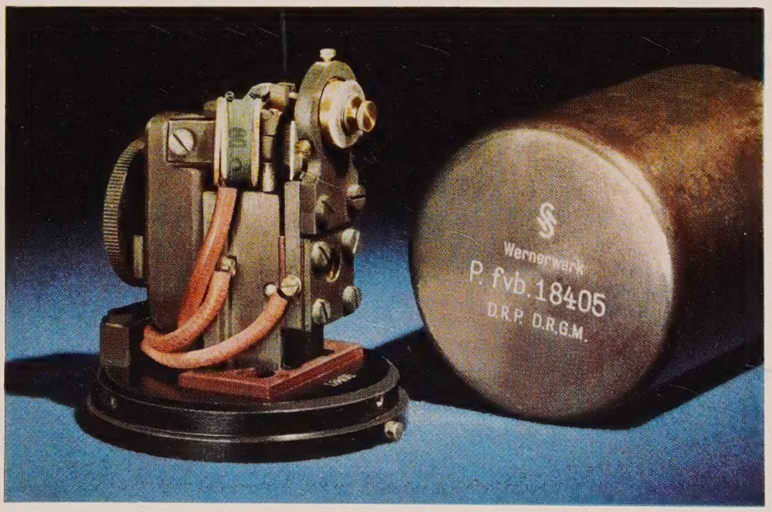


Fig. 1 Brown relay with cover removed

1910 may be considered as a particularly critical year in the history of the amplifier, for after remarkable preliminary work it was to see the construction of the first serviceable telephone amplifier, viz. the Brown relay. Parallel work was devoted to making the Lieben tube, patented in 1906, suitable for technical use. Its successor, the high-vacuum hot-cathode tube, finally marked a new phase in communications engineering.

Almost four decades were now to elapse before a new amplifying device appeared in the form of the transistor, which rapidly became a pace-setting element in information theory. Compared with the transistor, no other types of amplifier that have been developed over the years have attained anywhere near the same importance.

Amplifiers with a mechanically controlled medium

It appeared logical to combine a magnet system of a telephone receiver and a carbon microphone with a gain of about 1 : 1000 in such a way that a small strip of iron attached to the diaphragm of the microphone could be excited by the electrically energized magnet coils. Although this arrangement secured high gain, it exhibited a certain instability and the amplified signal suffered considerable distortion as compared with the control signal. Various other arrangements of similar design likewise failed to operate satisfactorily. These amplifiers, which the writer saw last in the year 1915, unfortunately no longer exist.

The 1910/1911 business report of the Siemens & Halske AG includes a contribution from the Cable Sales Department of those days which contains a reference to the telegraph relay invented by S. G. Brown, of England.

The actual quotation runs: "In our view the telegraph relay should make it possible to improve lines where only marginal intelligiblity exists to such an extent that perfect operation is achieved; every possible improvement is desirable." The great importance attached to these words is evident from the statement in the annual report of the following year that the Brown patents had been taken over by Siemens & Halske. Fig. 2 shows the circuit diagram of this Brown relay.

The energizing magnet system operated on a steel spring whose characteristic frequency of 5,000 cps lay far above the medium voice frequency of 800 cps. The small microphone attached to this spring was of special design, having a diameter about the size of the smallest German coin then in circulation. A specimen of this telephone relay – initially called a telegraph relay – may today be seen in the Siemens Museum in Munich.

Fig. 1 shows a model produced by Siemens & Halske in collaboration with S. G. Brown. The relay could be used in telephone circuits either as a terminal amplifier or as an intermediate amplifier. Although its initial adjustment appears not to have been easy, experience showed the relay to be very practical. This Brown relay would have certainly established itself but for the invention of the by far more elegant amplifier tube.

Amplifier with electrons controlled in an ion chamber

The 1910/1911 business report also referred to a telegraph relay of R. von Lieben of Austria, and to several months of collaboration with its inventor.

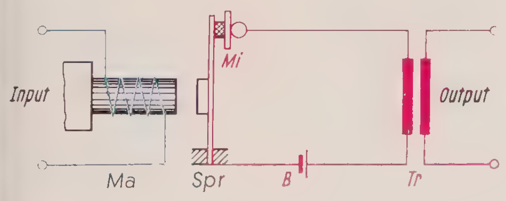
As early as 1906, R. von Lieben had already applied for a patent for his cathode-ray relay, which, however, could not thus far be effectively used as an amplifier (German Patent 179807 dated March 3, 1906). The second Lieben patent (German Patent 249142 dated December 19, 1910) achieved particular importance in that it for the first time permitted distortionless amplification with the aid of grid bias.

The same report also refers to the Gerdien patents (Prof. Gerdien was for many years the head of the Research Laboratory of the Siemens organization) in close connection with the Lieben patent.

In the 1912/1913 business report* we find the first reference to Lieben's telephone relay and to its possible use for telephone communication with England by way of a loaded cable. It is added, however, that more work still had to be done on this cathode amplifier. It should here be recalled that attempts were still being made in 1915 to improve the active layer of the hot cathode of the Lieben tube. This cathode was in the form of a platinum strip about 1 m in length, with a cross section of about 1 mm by 0.1 mm. To coat the overall surface with a durable active layer of barium oxide was no easy matter.

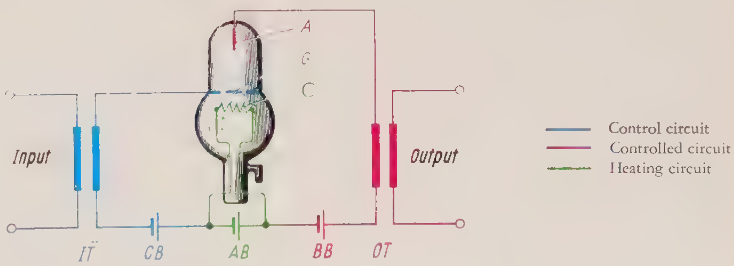
Fig. 3 shows the circuitry of the Lieben tube. Fig. 4 (left) is a cross-sectional representation of the last model of the Lieben tube with its coaxially arranged electrodes. The glass envelope was filled with mercury vapor. A tiny quantity of amalgam in a small tubular stub supplied

* The business reports referred to are all to be found in the Siemens Archives in Munich



Ma Magnet system
Spr Armored steel spring
Mi Microphone
B Battery
Tr Transformer

Fig. 2 Circuit diagram of Brown relay



IT Input transformer
OT Output transformer
A Anode
G Control grid
C Cathode
BB B battery
CB C battery
AB A battery

Fig. 3 Circuit diagram of Lieben amplifier

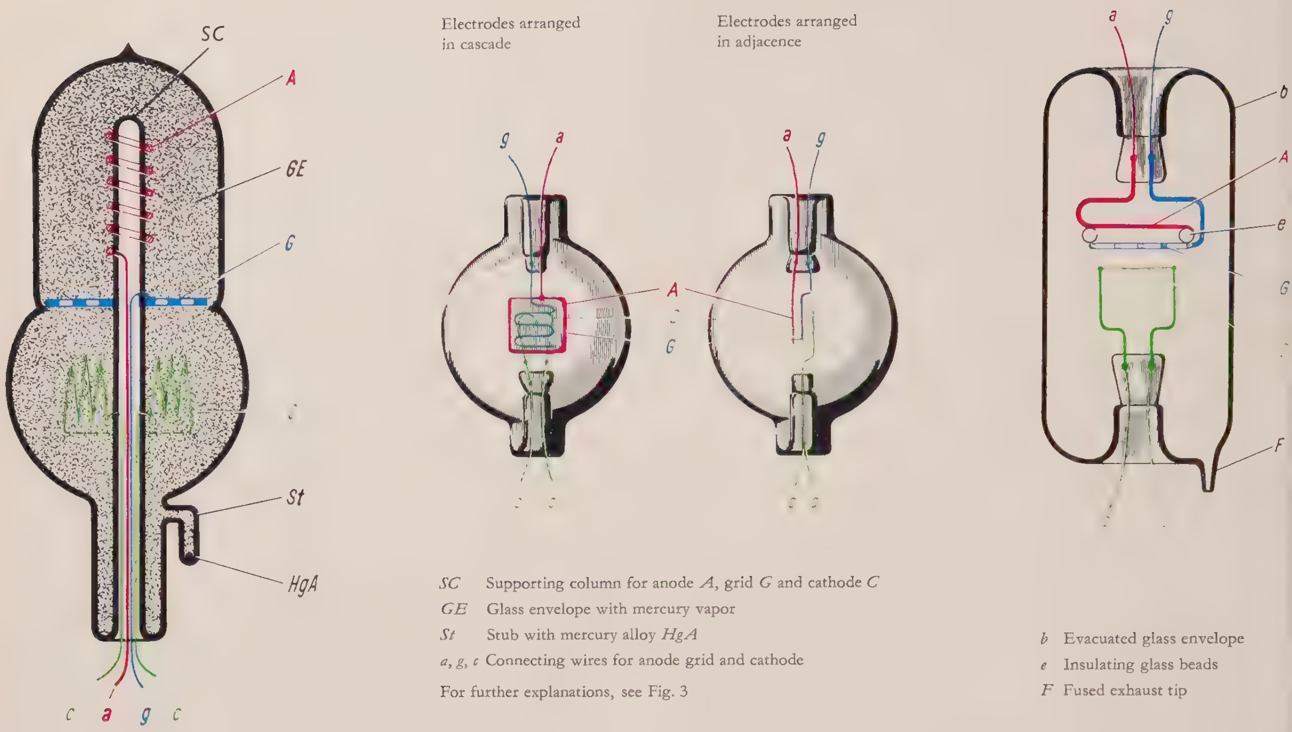


Fig. 4 Cross-sectional representation of Lieben tube without base (left), sketches of a De Forest triode without base (center), and cross-sectional representation of an A-tube without base (right)

mercury vapor as required. A drawback of this telephone relay was the dependence of the electrical characteristics of the mercury vapor upon the ambient temperature. Although this feature was known to all familiar with the Lieben tube, the tube was remarkably successful although soon to be superseded by high-vacuum hot-cathode tubes [1, 2, 3].

It should here be noted that Fig. 3 already represents the basic circuit arrangement of all subsequent amplifiers. At the input end we find for the first time the input transformer, which operates with a high step-up ratio into the high-ohmic cathode-grid section as against the relatively low-ohmic cathode-anode section with its matching output transformer.

Amplifier with electrons controlled in a vacuum

The triode for which Lee de Forest applied for a patent in the USA in the year 1907 was an audion-detector (USA Patent 879532 dated July 21, 1907 and German Patent 217073). Although the De Forest triode was already a hot-cathode vacuum tube, it probably did not have the high vacuum of the later hot-cathode tubes. As may be seen from Fig. 4 (center), however, this triode already embodied the three basic electrodes of amplifier tubes of this type. In the then upcoming radio technique it was successfully used as an audion. In contrast to this triode there was the hot-cathode tube on which Lee de Forest had taken out a patent as early as in 1906 (US Patent 841387 dated October 25, 1906); the control electrode was there still external to the cathode-anode section.

A remark in the 1913/1914 business report of Siemens & Halske deserves particular attention. It records that an attempt was made together with the then Experimental Telegraph Department of the German Post to use a De Forest audion as an amplifier tube on a 3-mm line of the previously mentioned Rhineland cable.

In the interim, basic work on high-vacuum tubes had been performed in America by I. Langmuir and was the subject of patents granted in 1915. In Germany independent development work was performed on the amplifier during World War I.

The first high-vacuum hot-cathode tube manufactured in Germany was the A-tube with three electrodes (Fig. 4, right). The cathode was in the form of a thin tungsten wire. The control grid consisted of a wire which, wound in the form of a flat helix, was united with the plate-shaped anode by means of several glass beads under high temperature. Amplifier tubes of this type were already being turned out in considerable quantities in 1915 by glassblowers employed at the Siemens Cable Laboratory. During evacuation they were then processed collectively on a bifurcated pump: a heated pump box accommodated two sets of ten tubes at a time along with their pump sets. The trap with carbon and liquid air applied in evacuating Lieben tubes was here likewise

used with success. This was also justified, for in those days only oil pumps were used for evacuation and mercury vapor air pumps had not yet been introduced. Although the molecular air pump was actually invented by W. Gaede, it was used only to a limited extent for the evacuation of these tubes.

Fig. 5 (left) shows an A-tube with bases and terminal contacts. In place of a helical grid, this tube had a simple sheet metal laminate grid arranged plane-parallel to the anode. This solution was chosen in view of the large quantities that had to be manufactured after B. Pohlmann (for many years head of the Central Laboratory of Siemens & Halske) had used this type of tube in designing a four-tube amplifier which rapidly found widespread application.

A further three-electrode tube – the Mc-tube – was manufactured by Siemens & Halske to the specifications of W. Schottky (head of the Tube Development Department of Siemens & Halske). It was of almost coaxial design in that the cathode wire was half encompassed by the grid and this in turn by the U-shaped anode. The grid was similarly punched out of sheet metal and then bent. The Mc-tube was the principal amplifier tube used in telephone applications for some time, but was superseded around 1919 by the more economically operating BF-tube (Fig. 5) [4].

As the result of theoretical studies and practical experiments, W. Schottky had, as early as 1915 and independent of I. Langmuir, suggested the space charge grid (German Patent 287745), a second grid between the cathode and the control grid. Such tubes require an anode voltage of only a few volts.

In 1916 W. Schottky designed an amplifier tube with a screen grid (German Patent 300617) inserted between control grid and anode. Its purpose was to reduce the reaction of the anode a-c voltages back upon the control grid. The hot-cathode tube embodying this screen grid became widely known as the Siemens-Schottky tube. It was quantity-produced and, as compared with the A-tube, had the advantage of operation with low anode voltage and low heating current. Its electron system was of completely coaxial design.

Whereas the A, Mc and BF tubes all had a tungsten wire as cathode, oxide was reverted to as a cathode material in subsequent models (BO, OR and Ba tubes). This technique drew upon papers by A. R. B. Wehnelt published in 1904 and was improved by Siemens & Halske in 1912. Oxide cathodes furnish a considerably higher emission for the same heating power; the gain of such tubes is, moreover, largely independent of fluctuations in heating current [5, 6].

In this connection reference should also be made to papers by A. Gehrts, which led to the first radio program tubes with oxide cathodes. These were the widely acclaimed RE 84 and RE 86. Tubes with an indirectly heated cathode should also be mentioned, representing as they did an economic solution to the always rather ticklish problem of tube heating.

The lifetime of amplifier tubes has, from the outset, always been a highly important consideration. The advent of the carrier technique further increased the demands made on tubes, and for broadband amplifiers special tubes were designed (Fig. 5) with an extremely favorable ratio between mutual conductance and the sum of input and output capacitances.

It would go beyond the scope of this account to discuss the tube theory elaborated in a classic manner in those days by W. Schottky and H. Barkhausen, and into the terminology they defined, some of which is still used to this day: mutual conductance, inverse amplification factor, internal resistance, etc. [7, 8]. These definitions made it possible for the first time to appraise and improve the quality and suitability of a certain type of tube. The exacting requirements imposed on tubes by long-line

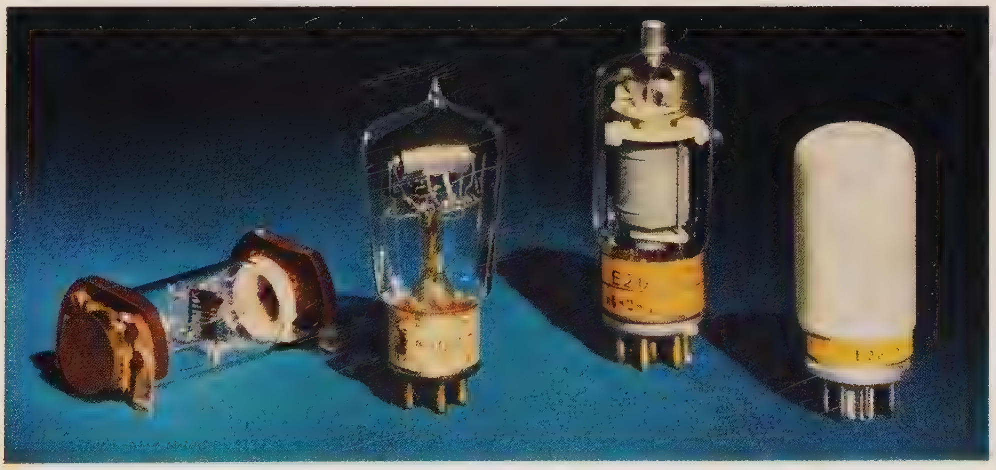


Fig. 5 Left to right:
A-tube with two bases and terminals;
BF-tube with three coaxially arranged electrodes and single-ended base;
first broadband tube (E 2b) and later type (E 2e)

Fig. 6 Transmitting tube for high power outputs, 1930 design

communications technology led very early to the creation of a special type of tube which, in comparison with the commercial types used in radio broadcast equipment, was designed with narrower tolerances, electrical characteristics of high stability, and long service life.

The production of high-power transmitting tubes has from the outset represented a special branch of tube technology in which a great many problems of technique are involved. H. RUKOP and K. MATTHIS both made basic contributions to the development of such tubes. Fig. 6 shows a high-power tube manufactured by Siemens & Halske in 1930. Tubes with power outputs of several hundred kilowatts are today nothing exceptional [9]. Their appearance, however, has undergone considerable transformation over the years due to the introduction of new materials and production techniques. While they have become smaller in size, more compact and more rugged, their range of application has at the same time been extended higher and higher into the spectrum (see [10], p. 252, Fig. 1).

The range and reliability of radio links has also been greatly improved at the receiving end through the development of low-noise tubes which can still be used even with very low input power levels [11].

Microwaves have of late also been placed in the service of radiocommunication. Both grid-controlled tubes in the form of disk-seal triodes and transit-time tubes (klystrons and traveling-wave tubes) are used in this portion of the spectrum. The disk-seal triodes are special models in which the introduction of the frame grid has made it possible to secure extremely narrow electrode spacing and hence short electron transit times [12]. Transit-time tubes, on the other hand, utilize the transit-time effects that are disturbing in normal tubes in what is basically an entirely different mechanism in order to secure amplification effects. The traveling-wave tube is here superior to the disk-seal triode both with respect to its maximum usable frequency and in its coverage of extremely broad frequency bands.

Amplifier with controlled magnetic flux

A distinction is here made between two amplifier types: Models with a static and those with a partially moving magnet system. Both models are relatively old and several inventors have concerned themselves with them over the years.

A few words should be said of the following old-time model that the writer saw around 1918: a number of copper disks arranged on a single shaft with interposed magnet systems are rotated rapidly by an electric motor, which represents the local source of energy. The a-c to be amplified energizes Foucault circuits in the first disk which act upon the second disk, and so on. The amplified current is drawn from the last magnet system. This amplifier operates, however, with very low efficiency.

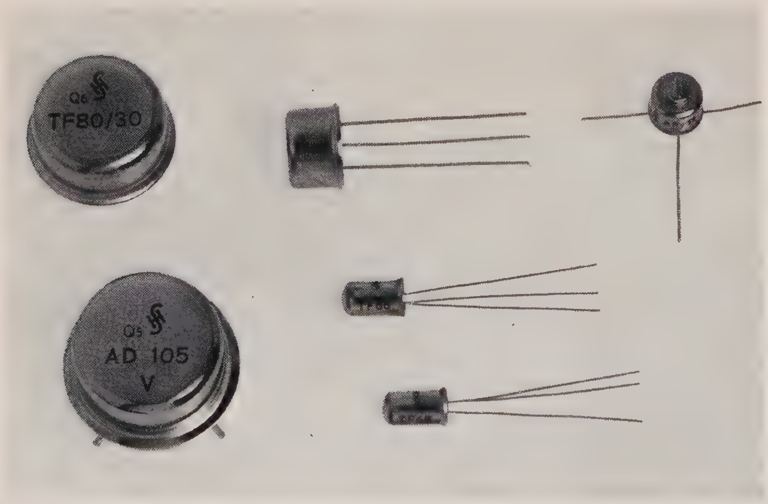


Fig. 7 Transistors for various applications

Amplifier with electrons controlled in a semiconductor

Over many decades the tube was the sole decisive element in amplifier technology and it is only recently that an other active amplifying device, the transistor (derived from the words transfer + resistor) emerged. Although it is still undergoing improvement, the transistor may already be said to have initiated a new phase in amplifier technology.

The original point-contact transistor has since undergone many changes with respect to both the configuration and type of semiconductors used; production techniques have also changed. Junctions with n-p-n or p-n-p conductivity have, for instance, largely superseded the point contacts on the semiconductor

which serves as the base; the purity of germanium and silicon has been increased and, finally, as reported by H. Welker in 1952 [13, 14, 15], combinations of the groups III and V of the periodic system of elements have been taken into consideration as suitable materials. The Siemens organization has played an essential part in the discovery of means of fabricating ultrahigh-purity silicon, which is also used in the fabrication of rectifiers.

Amplifiers operating with transistors (Fig. 7) have found a steadily widening field of application and entered into successful competition with tube amplifiers. The advent of transistors has, for instance, made it possible for the first time to arrive at economic solutions to problems in the field of electronic computers; tubes, nevertheless, will continue to remain indispensable in amplifier technology as before.

Although novel amplifying principles indicate that development has by no means come to a stop, it would go beyond the scope of this historical survey to treat of the new special-purpose amplifiers such as the parametric amplifier and the maser amplifier (**m**icrowave **a**mplification by **s**timulated **e**mission of **r**adiation) described by J. P. Gordon, H. J. Zeiger and C. H. Townes in 1955.

Bibliography

[1] Höpfner, K.: Fernsprechverstärker. Telegraphen-, Fernsprech-, Funk- und Fernsehtechnik 1913 (No. 16)

[2] Gruschke, G.: Die Entwicklung des Fernsprechverstärkers. Siemens-Zeitschrift **3** (1923) pp. 113 to 116

[3] Gruschke, G. and Pohlmann, B.: Fernsprechen im Weitverkehr. Druckschrift des Reichspostministeriums (1923) pp. 93 to 95

[4] Nottebrock, H.: Die Verstärkerämter Malmö und Stralsund. Siemens-Zeitschrift **2** (1922) pp. 433 to 436

[5] Pohlmann, B. and Gehrts, A.: Werdegang einer Verstärkerröhre. Elektrische Nachrichtentechnik **3** (1925)

[6] Haag, A. and Vogel, F.: 30 Jahre Siemens-Fernsprechverstärker. Siemens-Zeitschrift **21** (1941) pp. 26 to 43

[7] Barkhausen, H.: Lehrbuch der Elektronen-Röhren und ihre technischen Anwendungen. 1. Bd. Allgemeine Grundlagen. 4. Auflage, S. Hirzel, Leipzig 1931

[8] Graßl, L. and Schneider, W.: Weitverkehrsröhren. Mitteilungen aus der Röhrenfabrik der Siemens & Halske AG (1953) pp. 1 to 31

[9] Zenneck, J. and Rukop, M.: Lehrbuch der drahtlosen Telegraphie. 5. Auflage. F. Enke, Stuttgart 1929

[10] Branz, E.: Neue Sende- und Spezialröhren. Siemens-Zeitschrift **34** (1960) pp. 252 to 254

[11] Kleen, W.: Über die heutigen Grenzen der Elektronenröhren bezüglich Leistung, Frequenzen und Rauschen. Elektrotechn. Z. A **77** (1956) pp. 569 to 574

[12] Blume, M. and Hinckeldey, A.: Die Entwicklung der Scheibentrioden für hohe Frequenzbereiche. Siemens-Zeitschrift **33** (1959) pp. 723 to 728

[13] Dosse, J.: Der Transistor. 3. Auflage, R. Oldenbourg Verlag, München 1959

[14] Spenke, E.: Elektronische Halbleiter – Eine Einführung in die Physik und Technik der Gleichrichter und Transistoren. Springer-Verlag, Berlin–Göttingen–Heidelberg 1955

[15] Welker, H.: Über neue halbleitende Verbindungen. Z. für Naturforschung **7a** (1952) pp. 744 to 749

Circuit Arrangements for Strain-gauge Load-cell Weighing Installations

By Hubert Burster

For some years past, electrical load cells have been gaining more and more ground as sensing elements for weighing installations. Because of their robust and simple design, they are frequently preferred to mechanical balances of the classical lever-and-fulcrum type. It may even be stated that, when applied for the purposes of automation and production improvement, the electrical load cell has opened new fields of weighing engineering. Today, more weighings are taken than before.

The reliable operation of an electrical weighing installation not only depends on its load cells but, to the same degree, also on the circuit arrangements between the cell and the indicating device, which must be adapted to both, the characteristics of the load cells and the requirements of the process industries.

Measuring Principle

Load Cells

For simple weighing problems, such as measuring the contents of a tank, the magnetoelastic load cell continues to be of great importance [1]. The use of the strain-gauge load cell, however, becomes mandatory if only one of the following requirements must be met:

Tolerance better than 1%; summation of the measurement results of several cells in the case of an extremely non-uniform load distribution; variable tare; several measuring channels, e.g. by use of a dotted-line recorder; exactly linear scale, or application in automatic weighing installations.

The tolerance of precision strain-gauge load cells is about ±0.1% including non-linearity, hysteresis, creep rate, and temperature effects within a range of 50 degrees centigrade. This high accuracy is due to the use of choice material, correct dimensioning, application of adequate construction principles [2], and specially developed ageing methods in the manufacture. Of decisive importance is, moreover, the fact that the strain gauges are arranged in the form of a complete Wheatstone bridge with all compensating and balancing resistances. The different load cells shown in Fig. 1 are, e.g., adjusted for a sensitivity of 1.5 mv/v at nominal load, meaning that at nominal load a voltage of 1.5 mv will appear at the null branch for each volt applied to the bridge. The input impedance at the supply end and the output impedance at the meas-

Fig. 1 Strain-gauge load cells

uring end are 250 and 245 ohms, respectively. Two supply leads and two measuring leads are connected to each load cell. Thus, a quadrupole network with fixed input and output data is formed, an arrangement considerably facilitating the layout of clear and extensible circuits.

Basic Circuit

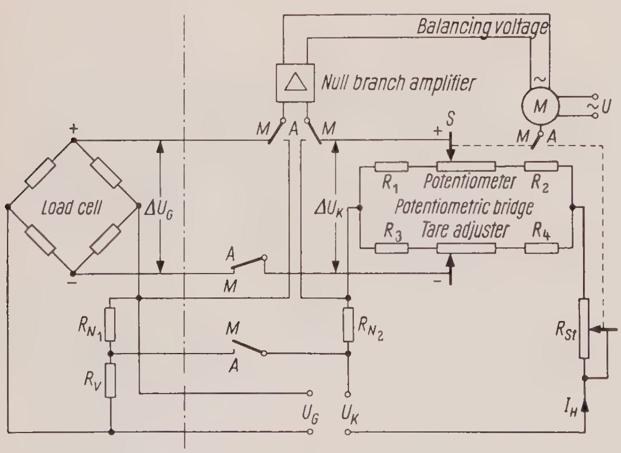
For accurate measurements in weighing installations, the principle of the self-balancing potentiometer has proved to be the most suitable. Fig. 2 shows the basic circuit of an analog potentiometer for measurements with strain-gauge load cells. The output voltage of the load cell is given by the equation

$$\Delta U_G \sim U_G\, P \qquad (1)$$

i.e., the output voltage is proportional to the product of the supply voltage U_G and the mechanical quantity P (e.g. the load) applied to the cell. Analogously, the output voltage of the potentiometric bridge is

$$\Delta U_K \sim U_K\, l \qquad (2)$$

i.e., the potentiometer voltage is proportional to the



A Contact position for standardizing
M Contact position for measuring
U Mains voltage
ΔU_G Output voltage of load cell
ΔU_K Output voltage of potentiometric bridge

Fig. 2 Basic circuit diagram of the self-balancing analog potentiometer for measurements with strain-gauge load cells

product of voltage U_K supplied to the potentiometric bridge and the potentiometer length l tapped off by the wiper.

Hence, the ratio between the two output voltages of the potentiometric bridge is

$$\frac{\Delta U_G}{\Delta U_K} \sim \frac{U_G}{U_K}\,\frac{P}{l} \qquad (3)$$

In the case of the measuring principle represented in Fig. 2, the potentiometric bridge need not be supplied from a constant current source. Neither the supply voltage U_G of the load cell, nor the supply source U_K of the potentiometric bridge (there is no galvanic connection between U_G and U_K) are regulated. Both voltages are taken from a common power supply unit. As a result, U_G and U_K as well as ΔU_G and ΔU_K will change to the same extent in the case of mains-voltage fluctuations. Thus, the ratio of U_G to U_K is kept constant to about $\pm 0.02\%$ in a very simple way. Hence, the relationship stated in equation (3) may be simplified as follows:

$$\frac{\Delta U_G}{\Delta U_K} \sim \frac{P}{l} \qquad (4)$$

If both bridge voltages are equal, the input voltage, and thus the output voltage, of the null branch amplifier are zero. Consequently, motor M and the wiper of the potentiometer, which is mechanically coupled with the motor, will stop. Any change of ΔU_G due to a variation of the mechanical quantity P will cause an input voltage to appear at the null branch amplifier. As a result, the motor will be supplied with a control voltage from the output of the null branch amplifier. This control voltage is in such a phase relation to the field voltage U that the resulting rotation of the motor and the displacement of the potentiometer wiper S will effect an approximation of ΔU_K to ΔU_G and, finally, the compensation with an accuracy better than $\pm 0.1\%$. Hence it follows that the length l of the measuring potentiometer, tapped off by the wiper, is a measure of the mechanical quantity P. The scale can be calibrated in kilograms per square centimeter, kilogram-meters, or per cent. In its balanced condition ($\Delta U_G = \Delta U_K$) no current will flow through the measuring circuit. Contact and line difficulties, which, owing to the d-c operation, would only be of ohmic nature, do not occur in this circuit. The calibration is based on a fixed relationship between the two bridge voltages. Of decisive importance for the installation, however, are not the voltages U_G and U_K of the common power supply unit, but the supply voltages U_G' and U_K' actually occurring across the bridge diagonal. While, in the potentiometric bridge, there is a definite relationship between U_K' and U_K, the ratio of U_G' to U_G frequently undergoes considerable changes. If several load cells are to be supplied in parallel, if great distances of say 1,000 meters or so between the

control room and the place of installation of the load cells are to be bridged, and, in particular, if both conditions happen to coincide, not only the line resistance (which, in some cases, may be allowed for when the equipment is being calibrated) but also its variation caused by temperature fluctuations is of consequence. For this reason, installations with strain-gauge load cells and self-balancing analog potentiometric devices are, in any case, provided with a standardizing device* which, at intervals of a few hours, throws the change-over switch in the circuit arrangement shown in Fig. 2 from its position M (measuring) to its position A (standardizing). The actual supply voltage U_G' of the load cell occurs at the voltage divider R_{N1}/R_V because the resistances of the latter are located directly at the place of installation of the cell. Hence, in as much as the voltage across R_{N2} is a measure of the supply voltage of the potentiometric bridge, the voltage across R_{N1} is in a definite relation to the actual supply voltage of the load cell. The calibration ensures that the two voltages across the standard resistances R_{N1} and R_{N2} are equal. In case of differences, the auxiliary current I_H, and consequently the voltage drop across R_{N2}, are corrected accordingly by the motor which, in switch position A, is mechanically coupled to the standardizing resistor R_{St}. By this adjustment of the auxiliary current, not only the influence of the line length is compensated, but also a general check of the complete installation is achieved. If the standardizing resistor R_{St} is adjusted to the end of its range, a contact is closed causing, e.g., a warning lamp to light up.

Taring

Practically, with every weighing device, a distinction must be made between gross weight and net weight. Frequently, the user is only interested in the net weight and wishes the difference between gross weight and net weight, called "tare", to be eliminated. In some cases, however, it is also desirable that the weight of the tare should be indicated separately. This can be achieved by balancing the resistances of the load cells (Fig. 3). The advantage of such a circuit arrangement, viz. its independance of voltage fluctuations, is opposed by the disadvantage that, in the case of considerably varying tares, the ensuing change of sensitivity (due to shunting of the wire strain gauges) will cause a perceptible reduction of the accuracy. For wide ranges, taring is, therefore, effected (for similar reasons as in the case of measurements by way of true compensation) by unbalancing the lower arm of the potentiometric bridge according to Fig. 2. The operator turns the manual tare adjuster – equipped with an eleven-point switch and a potentiometer for fine adjustment – until the pointer, which is coupled with the wiper of the measuring potentiometer, is adjusted to zero while the load cell is loaded with the tare. If, because of a continually varying tare, this adjustment must be made frequently and, what is worse, by untrained persons, it may prove to be rather inconvenient. Moreover, operating errors are not excluded because a zero adjustment with an accuracy of ±0.1% is not so easy to perform. Finally, it seems desirable that the time required for the manual taring operation should be saved. The desire to perform this operation automatically in the same way as the measuring process proper, viz. by a self-balancing method, was, therefore, attended to. As shown in Fig. 4, the servomotor M_T, connected to the output of the null branch amplifier in contact position T (taring), takes charge of the turning operation instead of the hand, while the voltage divider replaces the human eye. This is explained by the fact that, as to its potential, point S' is identical with the zero position of wiper S of the measuring potentiometer. The contacts having been changed over to their normal position M, a potential will initially appear at the input of the null branch amplifier because of the displacement of wiper S from its zero position. As a result, servomotor M will return wiper S to zero. The value of the tare, which is stored in the tare potentiometer, is fixed with the aid of a locking device switched into circuit in contact position M, simultaneoulsy with the motor. If desired, the tare can be indicated. The circuit arrangement of the automatic tare adjuster also enables a basic tare to be compensated in advance by manual adjustment, and only a desired portion of the tare to be indicated.

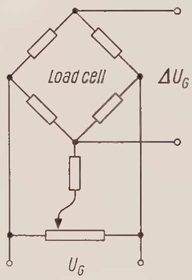
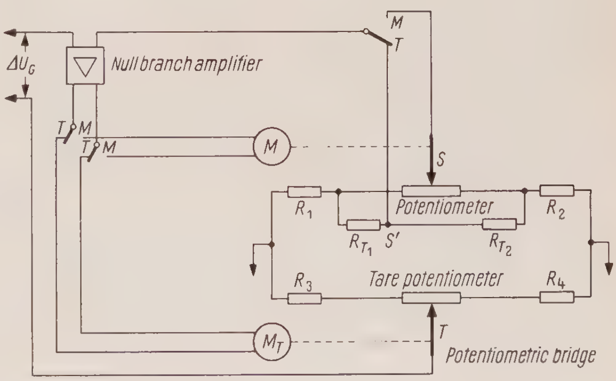


Fig. 3 Resistance-balancing procedure in strain-gauge load cells (because of line difficulties and variations in sensitivity only suited for small tare values)



M Contact position for measuring
T Contact position for taring

Fig. 4 Principle of the automatic tare adjuster

* German Patent D.B.P. 1045858

Structural Units of an Equipment with Self-balancing Analog Potentiometer

The individual units are shown in Fig. 5.

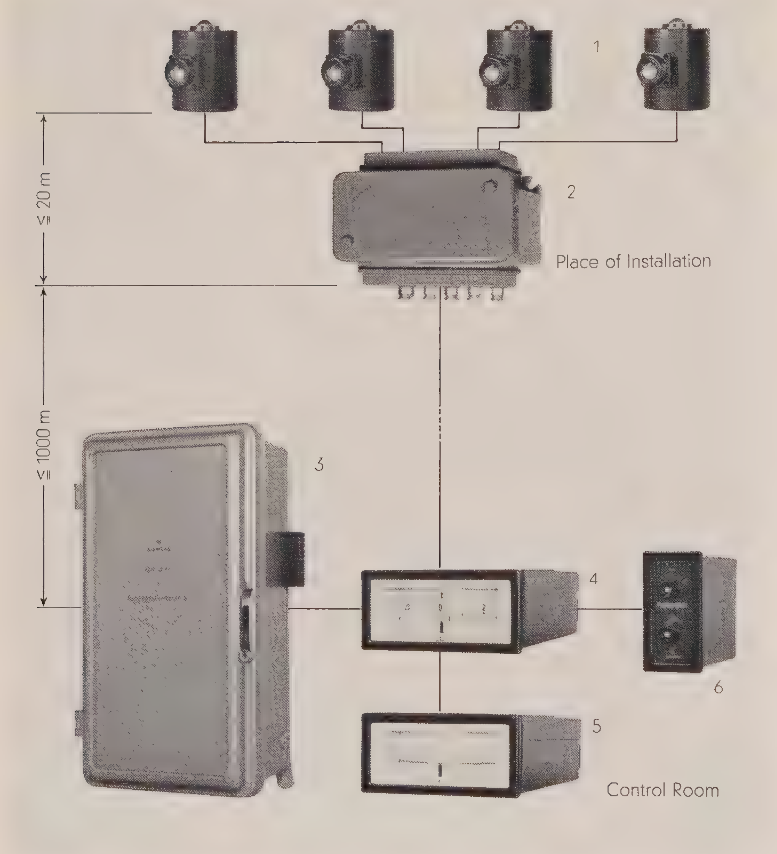
The load cells contain a complete strain-gauge bridge with fixed input and output data for different variables and different ranges.

The junction box, just like the load cells, belongs to the basic equipment of every installation. It not only serves as a transition point between the leads of the load cells and the permanent wiring, but also contains the above-mentioned voltage divider R_V/R_{N1}, which is, thus, accommodated in the proximity of the load cells. If the load values of several cells are intended to be totalized, the necessary parallel connections are made in the junction box by means of short wire straps. Also the circuit arrangement for scanning a number of load cells with the aid of a potentiometric dotted-line recorder can be accommodated in the junction box. In addition, the box contains a compensating potentiometer required for correcting the calibration of a balance by means of standard weights, a measure, by which the absolute accuracy of a weighing installation can be further improved.

The power supply unit for supplying the potentiometric and load-cell bridges is likewise a basic element of every weighing installation. It is always combined with the null branch amplifier to form one unit. Its normal output voltage is 2×6 v d-c.

The potentiometric bridge with null-balancing motor and measuring potentiometer is accommodated in the recorder or indicator used for the net-weight indication, i.e. in a Kompensograph* potentiometric dotted-line recorder, or in a large-size potentiometric indicator of type 432×432 mm (17×17 in.), or in a potentiometric indicator of type 192×96 mm (7.6×3.8 in.).

The amplifier and the power supply unit are enclosed in a common casing if merely an indication of the measured results is required (as shown in Fig. 5). In case, however, recording instruments are provided, the amplifier is accommodated in the housing of one of these instruments.



1 Load cells
2 Junction box
3 Power supply unit and null branch amplifier
4 Potentiometric indicator
5 Balancing unit
6 Tare adjuster

Fig. 5 Units of a simple weighing installation

The tare adjuster is intended for manually adjusting the tare. It is also manufactured in a heavier design than that shown in the illustration.

The automatic tare adjuster with potentiometer and servomotor is available as large-size indicator of type 432×432 mm (17×17 in.) and potentiometric indicator of type 192×96 mm (7.6×3.8 in). The last-mentioned space-saving instrument is preferably used if indication of the tare is not required.

In measuring installations with indicating instruments, the balancing unit with standardizing resistor R_{St} (Fig. 2) is accommodated, together with the necessary second servomotor, in a casing with trend indication of type 192×96 mm (7.6×3.8 in.). If potentiometric recording instruments of the Kompensograph type are provided, the balancing unit is incorporated in the recorder housing. In this case, the compensation of the auxiliary current is controlled by the paper feed, and the mechanical coupling of the balancing motor to either the measuring potentiometer or the standardizing resistor is realized as shown in Fig. 2.

As mentioned above, the units shown in the block diagram (Fig. 5) are those used for a very simple measuring installation

* Trade-mark

and should be regarded as the indispensable basic outfit of such an installation. Remarkable is the permissible distance of 1,000 meters (3,300 ft.) between the place of installation of the load cells and the control room. In spite of this considerable distance, the tolerance of such an installation is within ±0.3 per cent of full scale value. Every unit is individually calibrated and can be exchanged without recalibration of the other units being required. It goes without saying that the indicators and recorders can also be laid out for a desired partial range. If required, the potentiometric bridge and the circuit arrangement of the installation can be so designed that a negative change of the load results in a positive reading. The connection of additional units, such as printers, further recorders, relays, pilot lights, etc. is rendered possible by means of additional potentiometers and contact cams incorporated in the Kompensograph potentiometric recorders or in the indicating instruments.

By the addition of further units, a strain-gauge load-cell equipment can also be extended to form a semi-automatic or fully automatic weighing installation, used, e.g., for apportioning predetermined quantities or for measuring the rate of flow of solid bodies. The circuit arrangements described in this paper may also be used for other kinds of strain-gauge sensing elements, such as pressure gauges. In such cases, an accuracy of about 1% will frequently be adequate so that circuit arrangements based on the deflection method, which have likewise been developed for strain-gauge load cells, may be applied. The simplest and cheapest installation comprises nothing but a load cell, a junction box, a simple measuring circuit without amplifiers, and a switchboard-type light-spot indicating instrument. As a rule, however, also a magnetic amplifier is used, whose 10 or 50 milliampere output allows for the connection of practically all types of indicating, recording and controlling devices.

Bibliography

[1] Engl, W.: Magnetoelastische Kraftmeßdosen. Siemens-Zeitschrift **29** (1955) pp. 219 to 222

[2] Engl, W.: Mechanische Probleme bei elektrischen Kraftmeßdosen. Archiv techn. Messen (1960) R 13 to R 17

Motor-Generator Sets with Precision Current Control for Feeding Focusing Electromagnets

By Hans Gerhard Berger and Helmut Watzinger

In accelerators for nuclear investigations, particles (electrons, protons) are raised to high energies. After being accelerated, which e. g. in the case of the synchrotron is carried out in a circular path, the particle beam must be directed onto the experimental device.

For this are employed deflecting and focusing magnets which force the beam into a predetermined orbit. To ensure that the target is hit accurately, it is essential that the magnetic field and thus the current in the excitation winding of the magnet have a high degree of constancy. Since the particles are accelerated to various energies, it must be possible to adjust the field strength of the magnets, and therefore the excitation current, within a wide range.

This article contains a description of a power supply plant (Fig. 1) for focusing magnets which has been installed at Geneva for the European Organization for Nuclear Research (CERN).

General Features and Operating Conditions

The experimental hall for the 25-GeV proton synchrotron contains large numbers of deflecting magnets and four-pole focusing magnets. The rated excitation current of the standard designs varies between 625 and 830 A, with field time constants between 5.7 and 0.8 seconds. Magnets with lower excitation currents and time constants down to 0.15 seconds can also be used. The power is supplied by thirty d.c. generators: for small magnets by eight 105-V, 415-A generators, and for standard types by fourteen 205-V, 830-A generators and eight 405-V, 830-A generators.

The current is to be variable between 10 and 100% of the rated current. At any set value the degree of constancy shall be ±0.1%, i.e., at 10% of the rated current it is to be 0.01% of the rated current.

The following disturbances are present: system-voltage fluctuations and slow changes in the characteristic quantities of the control circuit and controlled system due to temperature rise.

Principle of the one-part per thousand current-regulating system

Even with an extremely fast controller it is not possible to prevent transient deviations of more than ±0.1% on the occurrence of fluctuations in the system voltage. The obvious solution to the problem was therefore to

Fig. 3 Motor-generator sets installed at the European Organization for Nuclear Research (CERN) in Geneva

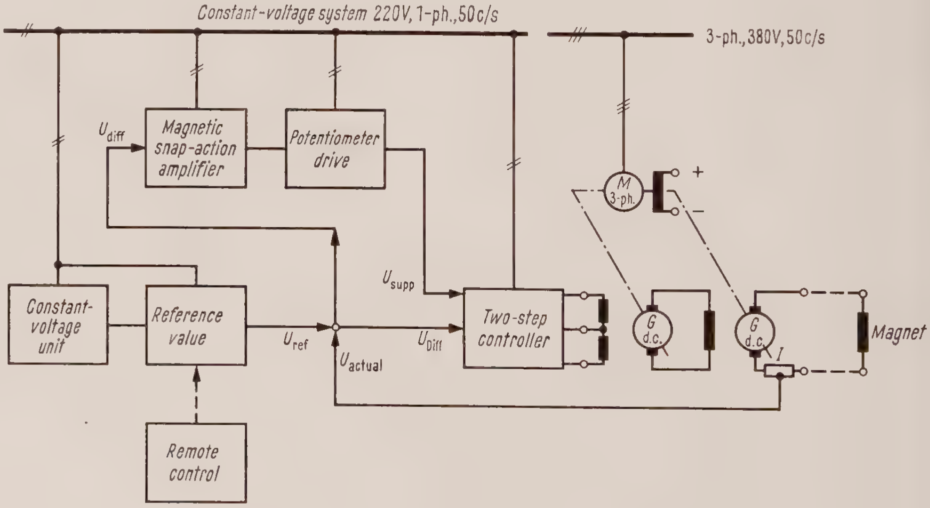
design the plant so as to obviate any effects due to system-voltage fluctuations. The slow changes due to temperature rise and to slowly developing frequency deviations can then safely be kept within the one-part per thousand limit.

Fig. 2 shows the basic arrangement for the current-regulating system. The generator for feeding the magnets, which acts as a power stage, is designed with a flanged-on exciter. Both machines are driven by a synchronous motor in order to eliminate the effect of system-voltage fluctuations. The exciter is separately excited by a transistorized two-step controller operating in a push-pull arrangement. The mains part of the controller and other auxiliary circuits of the one-part per thousand current-regulating system are supplied from a constant-voltage auxiliary system.

The d.c. reference value is set on a precision-type potentiometer which is supplied from a Zener-diode constant-voltage unit.

The actual value of the d.c. current is measured across a precision shunt in the d.c. circuit, since arrangements employing d.c. current transformers, Hall generators etc., do not provide the required degree of accuracy. The voltage available is limited by the I^2R losses of the shunt. The shunts used are for 830 mV at rated current. At 10%

Fig. 2 Basic arrangement of the current-regulating system



of rated current the difference between the reference value and actual value should therefore be approximately 83 microvolts. However, consideration must also be given to the tolerance of the constant-voltage unit and to temperature changes in the components of the reference circuit. The working point and temperature curve of a normal d.c. transistor amplifier make necessary, however, an input voltage of a few millivolts. On the other hand, it is desirable to employ a high-speed and continuously variable controller, the output voltage of which contactlessly varies the excitation current. For this reason a combination of a high-speed continuous-action controller and a slower, highly sensitive snap-action magnetic amplifier (three-point controller) was selected.

As shown in Fig. 2, the same differential voltage U_{diff} is applied to the input of the snap-action magnetic amplifier as to the input of the two-step controller. The three-step magnetic amplifier has a sensitivity of approximately ±20 microvolts. The two output stages (push-pull) each act on a relay which adjusts a potentiometer drive. The supplementary voltage tapped off is fed to the input of the transistorized two-step controller. If, therefore, there is a deviation in the actual current value due to a temperature change in the two-step controller, the snap-action magnetic amplifier operates and adjusts the compensating current until the voltage difference again falls below the response value. Fig. 3 shows part of a chart recording of a long-time measurement of the current across the shunt.

Design of the plant

All of the motor-generator sets, the associated low-voltage switchgear for the incoming feeders from the three-phase a.c. system, the control boards and the controller cubicles are accommodated in a machine hall immediately adjacent to the large experimental hall. By means of a line selector developed by CERN the generator circuits can be connected to the d.c. terminals in the experimental hall as required. The shunts are arranged below the line selector.

All power, excitation and control cables are installed on cable racks in 1.2 metre deep ducts between the foundations of the motor-generator sets. In addition to this, the ducts serve to supply fresh air to the sets.

In experimental operation a large number of generators are required simultaneously for feeding the magnets. For this reason, the generators of low and medium ratings are in each case coupled in groups of two to a common synchronous motor. The synchronous motors are designed with starting windings for direct-on-line induction starting.

All of the d.c. generators are of standard design. To permit parallel operation, the generators for 405 V, 830 A, have additionally been provided with differential series windings.

In order to keep the ripple content of the generator voltage to a minimum, all generators have been designed with skewed armature slots and a large main pole gap. At 10% of rated voltage and at rated current, the ripple content of the generator voltages is between 0.15 and 1.2%, according to the type of generator.

The motors and generators of all sets are self-cooled. Since the motor-generator sets are installed close together, the air intake openings are arranged on the side or bottom, the hot air being discharged vertically at the top.

An additional motor-generator set with a constant-voltage synchronous generator serves to supply power to the controllers.

The synchronous motors are connected to a metal-clad low-voltage switching station with 15 panels, the three bus sections of which are each fed from the 18-kV system via a 2-MVA transformer. The standardized panels afford the advantage of limited space requirements, simple installation and easy extensibility. The drawout equipment units can be removed without interfering with other circuits. All switchgear is operated by compressed-air drives and can be controlled locally or remotely. The entire switching station is designed for initial symmetrical short-circuit currents of 50 kA r.m.s.

Control of the motor-generator sets, switching in and out of the magnet excitation and setting of the current value and direction is effected from the control board. The d.c. circuits can be controlled remotely from both the central control room of the experimental hall and from transportable control units. A suitable system for this was developed by CERN.

The generator current can be set at two speeds by means of the remote-controlled reference potentiometer. On coarse setting, the entire range is traversed in approximately 1 minute. At the slow setting speed, at which approximately 30 minutes is required to traverse the entire range (0.05% per second), it is possible to set the current with an accuracy of down to 0.01% of the rated generator current, according to the degree of accuracy required.

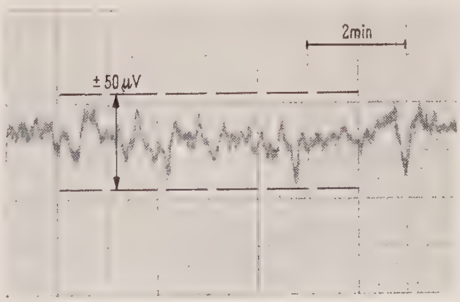


Fig. 3 Long-time measurement of current change at 10% of rated current (±50 µV ≙ ±0.06 %)

Fig. 4
Controller cubicle with slide-in trays

On account of the high inductance of the magnets, no automatic circuit breakers were installed in the d.c. circuits. The switching in and out of the magnets is therefore carried out by means of remote-controlled short-circuiting switches in the line selector. With the generator de-excited (electrically interlocked) the generator connections behind the shunts are short-circuited. It is then possible to disconnect the magnets and make reconnections without shutting down the motor-generator set.

In the event of short circuits and overcurrent, the generator is protected by relay combinations. These initiate high-speed de-excitation with double field weakening and shut down the motor-generator set. Further relays and indicating devices are provided for earth leakage supervision and for thermal overload protection of the motor and generator excitation circuits. On the development of faults in the power-supply system for the magnets, supervisory devices trip the supply and initiate an alarm.

Instruments in the control boards permit coarse setting and supervision during operation. Digital voltmeters connected to the precision shunts are used to measure the current with an accuracy of 0.1%. With the digital voltmeters it is possible to measure shunt voltages between 0.1 millivolts and 1 V which correspond to currents between 0.1 A and 1,000 A.

The transistorized two-step controller is constructed on the slide-in tray principle. The magnetic snap-action amplifier with the motor-driven potentiometer, the components of the reference circuit (excluding constant-voltage unit) and a device for measuring the controller disturbance are accommodated in a single slide-in tray. A further tray contains four constant-voltage units with the associated variable resistances. Thirty control units are built into eight cubicles (Fig. 4).

3 Million EMD Telephone Terminals

By Konrad Rohde

In the telephone switching technique of the future, a great many new potentialities are expected to result from electronics. Those responsible for adapting the capacity of telephone networks to the steadily increasing demand for telephone lines, however, are unable to wait for what the future may have to offer in this respect. They have to install new telephone lines daily and provide the dial offices for local and long-distance traffic; they have to invest millions daily and are confronted daily by the same problem as to which of the switching systems today available justifies such outlay.

Their decisions are reflected in the statistics covering the sales of telephone switching systems that have been in keen competition with each other on the international market for some ten years. The EMD technique here occupies a leading position. By now EMD equipment for nearly three million terminals have been placed in service or ordered by telephone administrations, civil services and industrial organizations in all parts of the world.

This success of the EMD technique must be ascribed to its operating reliability and flexibility. Since each new dial office affects, as part of a worldwide telephone network, not only the existing structure of that network but also its possibilities of future development, operating reliability and flexibility have become determining factors in the choice of new dial system equipment.

The operating reliability of a telephone switching system is reflected both in the number of terminals ordered that operate on that system, and in the statistics furnished by telephone administrations on the outlay for the maintenance of their switching equipment. One of the most favorable sets of statistics to be published was that concerning the EMD technique: as outlay

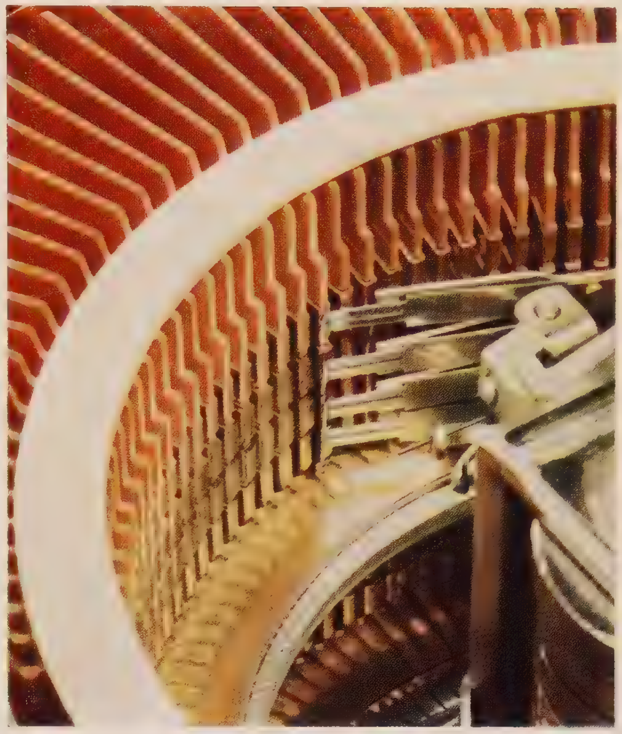
for the maintenance of local EMD dial offices, the West German Post has quoted a guiding figure of 0.37 hrs per year and subscriber line [1]. For other modern switching systems figures of 0.4 to 1 hr per year and subscriber line have been published [2 to 5]. The extraordinarily low outlay for maintenance in the case of the EMD technique is due, among other things, to the advantages that all the contacts in its talking paths are made of a palladium-silver alloy, and that thousands of soldered joints are saved per dial office through the use of the solderless EMD multiple.

The flexibility of a telephone switching system is reflected in large measure in the latter's influence on the existing structure of the dial office network and on future development potentialities. Switching systems that are readily adaptable to any of the operating principles encountered in present-day dial offices and that allow full freedom in future network development will naturally best justify current investments in the worldwide telephone network, which is being expanded at the rate of about 20,000 new telephone lines daily.

Both criteria of flexibility – adaptability to the operating principles of existing dial offices and avoidance of features that would impede future network development – call for a switching system that has the fewest possible features that are specialized in a particular direction. In switching technology it is said that the best system is one that is in no way one-sided with respect to either direct or indirect control, link systems or exclusively single-stage trunking, certain traffic or certain subscriber densities, certain multi-frequency dialing or certain storage methods, certain numbering principles or any form of limitation in the length of call numbers.

With respect to adaptability, the EMD technique offers every conceivable potentiality. This is already evidenced by its wide range of application in many countries throughout the world [6, 7, 8]. The standard versions of switching devices that operate with EMD switches admit of either direct or indirect control and can be used in either single-stage or multi-stage switching arrays – hence also in link systems – and adapted to all traffic densities and subscriber densities of interest; they also do not demand the observance of special numbering principles such as limitation of the length of call numbers. For all the features mentioned, and more besides, it is possible to quote practical examples of local and long-distance EMD dial offices which are giving excellent service.

With respect to the influence of a switching system on future network development, the primary factors here are flexibility with respect to traffic density and subscriber density and freedom with respect to the length of call numbers [9]. All the other features of current switching systems are of but secondary interest, for they will in any case have to undergo basic modification when semi-electronic and full-electronic switching systems are introduced.



Inside view of contact bank of EMD switch

EMD equipment can be adapted to any traffic density and subscriber density without its switching and control devices having to be modified. Its greatest advantage, however, is that it imposes no restrictions with respect to the length of call numbers: it permits, as a basic principle, the unlimited expansion of numbering.

Some experts argue against an unlimited numbering capacity by pointing to the features of indirectly controlled dial systems, i.e. dial systems operating with registers and markers, that have always held considerable interest. The main contentions are that the storages and registers of such systems cannot basically be designed with an unlimited numbering capacity, and that sufficient foresight in planning should make it possible to set a maximum limit to the length of call numbers which it would at present be unrealistic to exceed.

The first contention concerning the numbering capacity of storages and registers is not at all decisive. Dial systems in which call numbers of any length can be used are today technically feasible through the application of, say, buffer storages [10,11]. This is, in fact, a basic feature of the EMD system operating with indirect control; in the case of direct pulsing, of course, the use of call numbers of any length is possible from the outset.

A reply to the second contention was recently published in the Siemens Review in connection with the problem

of direct inward dialing to PABX extensions [12]. It was explained that if the numbering system of a country has to be limited to call numbers with a maximum of 10 or 12 digits on account of the existing registers, it is obvious that a system allowing call numbers of any length (and which is, moreover, not more expensive) must be more advantageous. This is all the more true when the extension of direct distance dialing to other countries and continents is considered.

The probable growth in telephone lines throughout the world and the increasing requirements with respect to the organizational coordination of these lines in the face of the increasing differences between present-day national economic structures cannot be predicted with any certainty for a period longer than a decade. This alone is sufficient reason to avoid creating more new systems having a fixed numbering capacity. No problems at all will then arise for full-electronic dial systems, while for semi-electronic systems satisfactory solutions are offered by high-speed switching arrays that operate at switching rates faster than 5 msec [13, 14].

All versions of the EMD technique already take due account of this situation. Thus the EMD technique offers all the degrees of freedom that must be demanded in connection with current investments for switching plant with a view to future developments. Millions of EMD terminals eloquently demonstrate this point.

Bibliography

[1] Müller, H.: Appraisal of Switching Systems According to Quality Coefficients. SH 7915 E
[2] Ahm, H.: Instandhaltung und Betriebsbeobachtung in der Netzgruppe Aarhus. Ericsson Review **34** (1957) pp. 2 to 8
[3] Cronsten, G.: Maintenance of Unattended Automatic Telephone Exchanges. Tele (1957) No. 2, pp. 22 to 31
[4] Telefonaktiebolaget L. M. Ericsson: Automatic Telephone Exchanges with Crossbar Switches. Stockholm 1958, Book B 10247
[5] Lucantonio, F.: Development Trends in Modern Switching Systems. Reprint of article in Frequenz **9** (1955) pp. 339 to 351
[6] Abart, J.: Das Wählsystem 55. Nachrichtentechn. Z. **10** (1957) pp. 439 to 449
[7] Laas, K. and Meigel, H.: EMD Dial Offices Inaugurated in USA. Siemens Review XXVI (1959) pp. 1 to 5
[8] Etzel, F.: Flexibility in Automatic Telephone Systems. SH 5081
[9] Töpfer, H. and Brandstetter, A.: The EMD Switch in Dial Offices. Siemens Review XXVII (1960) pp. 185 to 188
[10] Töpfer, H. and Laas, K.: A Local EMD System Using Individual Buffer Storages. Siemens Review XXV (1958) pp. 182 to 185
[11] Franzen, J.-F. and Vogel, H.: Siemens Dial Pulse Repeater. Siemens Review XXV (1958) pp. 238 to 241
[12] Töpfer, H. and Rohde, K.: Direct Inward Dialing to PABX Extensions – A Dial Office Problem? Siemens Review XXVIII (1961) pp. 217 to 222
[13] Panzerbieter, H.: Ein Beitrag zur künftigen Entwicklung der Vermittlungstechnik. Jahrbuch des elektr. Fernmeldewesens **10** (1958) pp. 73 to 108. Verlag Heidecker, Windsheim (1959)
[14] Panzerbieter, H.: Elektronische Vermittlungstechnik. Elektrotechn. Z. A **81** (1960) pp. 881 to 889

Distribution Centre N 1960 —

a Flexible Low-voltage Metal-clad Distribution Board with Drawout Units

by Herbert Lausmann and Josef Schmitt

The metal-clad type of low-voltage switchboards[1] for installation direct in factories and workshops has proved its reliability in service. It is nowadays not uncommon even for switchboards for high current ratings in the space-saving metal-clad design to be installed in the load centres, i.e., right in the middle of factory workshops. The central location of the distribution switchboard affords a considerable saving in assembly and erection costs and a reduction of the power transmission losses. The introduction of automatic equipment in modern industrial plants confronted the electrical engineer with new problems, in addition to the distribution of energy, e.g., the remote control of drives. An advantage of this type of switchboard or "motor control centre" is that the motor control units can be favourably designed and arranged. Moreover, the operating reliability has been so improved that faults and prolonged interruptions of power supply are avoided. A prerequisite for this is the availability of high-grade switchgear as well as a reliable and functional construction of the switchboard. The requirements to be met in actual operation are the following:

In operation: simple maintenance and supervision; the possibility of replacing faulted equipment by spares immediately available

For reconstruction: the possibility of easily extending existing switchboards and of exchanging equipment units of different sizes (flexibility)

Modifications to electrical distribution systems may, for instance, be necessitated by changes in the manufacturing programme, which frequently occur in modern industries. The possibility of completing such modifications in a minimum of time without endangering the personnel is of primary importance.

These requirements are met by the new Siemens-Schuckert distribution centre N 1960, a flexible

1 Floerke, H.: Sheet-steel Clad Low-voltage Switchgear for 500 V a.c. Siemens Review XXIII (1956) pp. 68 and 69

low-voltage distribution switchboard with drawout-type equipment. The switchboard complies with VDE 0100/11.58 "Specifications for the erection of power installations with service voltages up to 1,000 V". The clearances, striking and creepage distances were selected in accordance with VDE 0110 Specifications for Class C equipment for industrial and agricultural applications.

Basically, the new distribution switchboard has been designed for the following electrical values:

Insulation rating	1,000 V, 50 c/s
Voltage rating, a.c.	500 V, 50 c/s
d.c.	600 V
Max. current rating	
of busbars	3,500 A
of switchgear	3,000 A
Mechanical short-circuit rating (crest)	100 kA
Types of enclosure*	P 30 and P 40

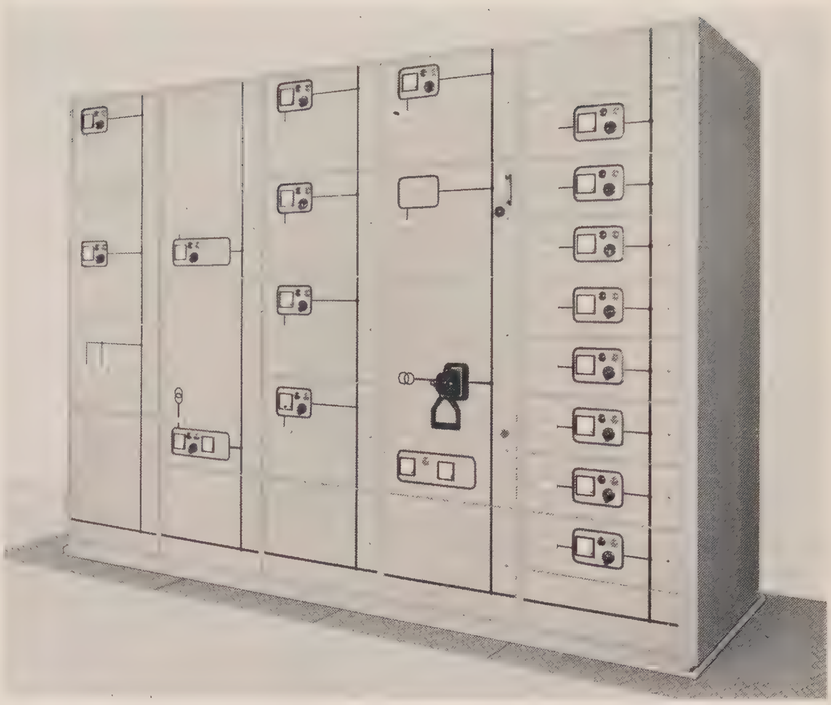


Fig. 1 Low-voltage distribution centre, type N 1960

The framework of the new distribution switchboard consists of sections which are bolted together. The identical, mass-produced frame sections of 2.5 mm thick sheet steel are provided with all the drilled holes necessary for the flexible arrangement of equipment. These drillings also allow further panels to be added. The frame sections assembled with the upper and lower cover plates provide a robust framework which can be extended as desired after side cover plates have been removed. The height of the frame is 2,225 mm (7′4″), the uniform panel width 600 mm (2′), the total depth 1,000 mm (3′3″). As can be seen in Fig. 2, the apparatus units are accommodated in the space behind the operating front, which also permits the control cables and smaller power cables to be taken to the equipment from the side. The space behind the equipment compartments accommodates the arc chambers of the heavy switchgear, the busbars and the outgoing cables of medium and large cross sections.

The basic subdivision of a panel allows for a maximum of 10 sections (equipment units), arranged one on top of the other. Depending on the size of the equipment to be installed, the height of one drawout unit may be a multiple of the height of one basic section (see Fig. 2). With these subdivisions, units of four different heights ($^1/_{10}$, $^2/_{10}$, $^3/_{10}$ and $^4/_{10}$ of the total panel height) are obtained, the width being uniform throughout. These dimensions also determine those of the various doors, the cover for the rear side having a height equal to $^5/_{10}$ of the total panel height.

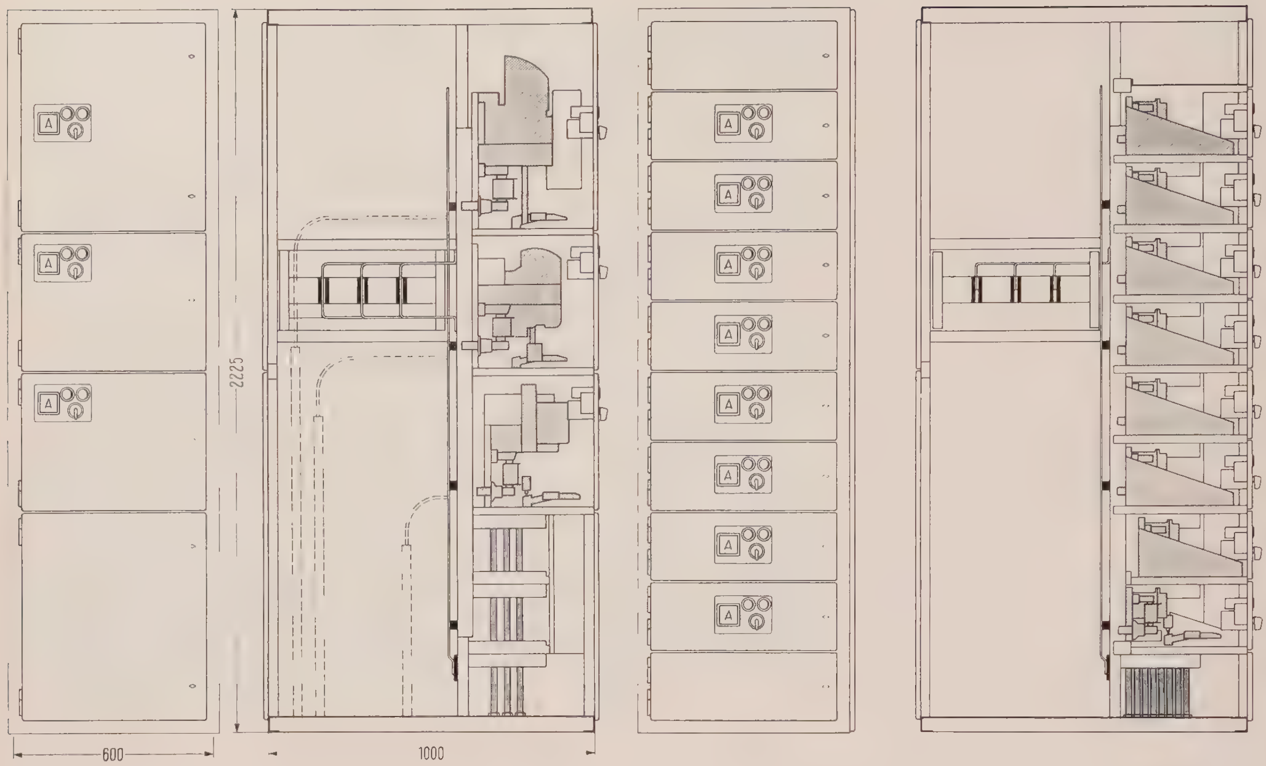
The main busbars are secured by means of the well-proven arc barriers which have a high short-circuit strength and prevent any fault arcs from affecting adjoining sections.

The flexible arrangement of equipment in the new l. v. distribution switchboard has been made possible by the holes provided in the framework as described and by the vertical busbars which are fitted in the individual panels and permit the equipment units with isolating contacts (contact set) for outgoing circuits up to 600 A to be inserted at any elevation desired. This obviates the necessity of altering the basic construction of the framework and of the position of the bars if, for instance, a large apparatus unit is to be replaced by several smaller ones.

For the drawout equipment, a difference is made between basic apparatus units up to 600 A and those with ratings above 600 A.

With the units incorporating switchgear up to 600 A, the apparatus assembly comprising, for instance, automatic circuit breakers or air-break contactors, l. v. HRC fuses, current transformers, relays, control switches and signalling devices, is mounted on slides. These are made of steel sheets with the edges turned in and have an easily operable latching mechanism by means of which the unit

* P 30 enclosure: Protection against contact with tools, etc., and small solid foreign bodies; no protection against water.
P 40 enclosure: Protection against contact with implements of all kinds and harmful dust deposits in the interior.



Section through a panel with automatic circuit breakers and contactor unit (contactor withdrawn into test position)

Section through a pane lwith eight contactor units

Fig. 2 Examples of basic panel arrangement

can be arrested in different positions. The contact set connecting the power circuits to the vertical busbars of the panel is arranged on the left-hand side of the unit (Fig. 3). The adjoining contact set serves for connecting the apparatus unit with the cable lugs mounted on the frame.

The design of the housing of automatic circuit breakers for higher current ratings permits their direct installation as self-contained drawout units. The latching mechanism used basically corresponds to that of the units up to 600 A. The automatic circuit breakers are connected to the main bus through isolating contacts which are of the resilient jaw type ensuring reliable contact in any position.

The apparatus units of both types can be moved from the operating position into a test position in which the

Front view

Rear view with contact set for incoming and outgoing circuits

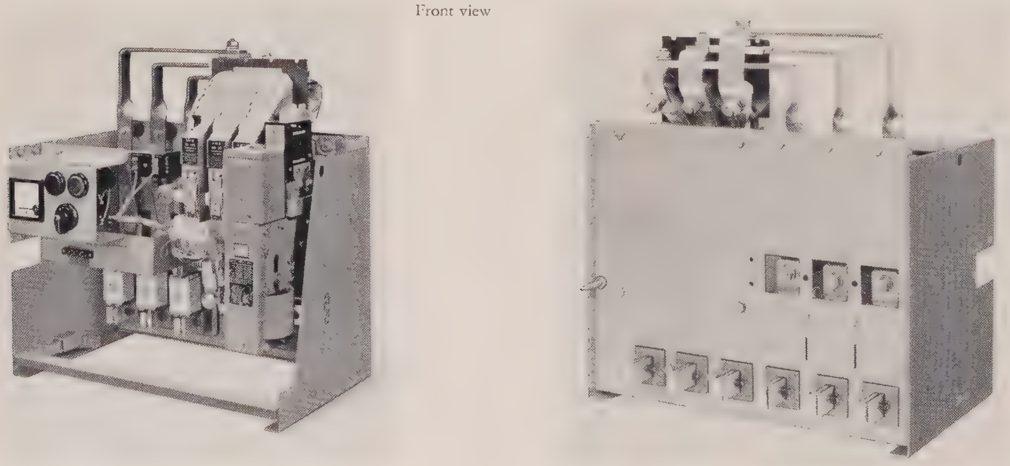


Fig. 3 Unit with 600-A automatic circuit breaker

equipment is disconnected from the mains. When in the operating position, the incoming feeders and outgoing circuits can be switched even while the doors are open, so that the switchgear may be inspected during operation. After the latching mechanism has been released, the unit may be withdrawn into the test position, where it is arrested. In this position, the equipment can be tested with the control circuits connected to the auxiliary supply. The locating mechanism also prevents the equipment from being withdrawn while live. In the test position, the isolating contacts of the power circuits have a safe clearance from the vertical busbars, so that the control circuits may be checked for proper functioning without endangering the personnel.

The auxiliary circuits of the apparatus units and automatic circuit breakers are supplied through flexible cables and multi-pole plug-and-socket couplings. After the latter have been disconnected and the sliding cover of the control and indicating devices pushed back, the switchgear of the unit is dead, the switchgear being so arranged that the doors may be closed irrespective of the type of operating mechanism used. The doors have a cutout through which the control and indicating devices mounted on the cover can be checked and operated both in the operating and disconnected positions of the unit.

An interlocking arrangement is provided which prevents the switchgear from being withdrawn inadvertently.

The N 1960 distribution centre of the design described fulfils all demands arising in operation. By reason of its flexibility, it offers substantial advantages to the plant designer.

Intrusion Detection by Electromagnetic Fields

By Sven Wirén

It has long been common practice to protect rooms from unauthorized entry by means of electrical circuits that are monitored at a central point. The windows and doors of rooms to be protected can, for instance, be provided for this purpose with contact devices through which closed-circuit current flows. The opening of any window or door will then trigger these contact devices, thereby acting upon the closed circuits. A monitoring relay that operates to this condition originates an alarm at the guard station. Although systems of this type afford adequate protection against forced entry, no alarm is originated until an intruder actually enters the guarded area. In many cases, however, it is desired that an alarm be given whenever the guarded area is approached. The objective here may be to secure that the intruder is detained before he has time to commit damage. This class of protection is possible by surrounding the guarded area (rooms or objects) with electromagnetic fields. Any intruder will inadvertently bring about a variation of such fields and this condition can be used to originate an alarm by way of an indicator. In the following we shall first describe the operating principle of an electromagnetic intrusion detection system designed by Siemens & Halske, and then go on to discuss the design features and functions of intrusion detectors.

Electromagnetic intrusion detection

Electromagnetic intrusion detection is based on the concept that the capacitance of an air capacitor composed of two metallic electrodes undergoes a change when matter with a dielectric constant different from that of air comes within the vicinity of the electrodes. If, for instance, a number of electrodes spaced a certain distance apart are arranged in a row and their inter-electrode capacitances are monitored, an area shielded against interference results. Fig. 1 shows various examples of such an arrangement. As the absolute value of the capacitance may gradually change, it is necessary to design the detector circuit so that only sudden variations in capacitance will produce an alarm. A Wheatstone bridge of balanced design was here chosen; the electrodes used for area protection form part of the bridge. Symmetrical interference effects are largely compensated by circuit design. As protection systems require supervision of their internal circuits, the capacitive bridge is biased in the no-alarm condition so that a voltage other than zero flows in the detector arm. Variations of this voltage due to effects that act upon the inter-electrode capacitances are interpreted as alarm conditions.

The inter-electrode capacitances do not remain continuously constant but may vary gradually due to fluctuations in temperature and humidity. A differentiating circuit prevents minor variations in capacity per time unit from originating an alarm. The range within which the voltage in the detector arm is differentiated is limited at the top and bottom by a maximum-minimum monitor and can be varied.

A checking pulse unit guards against sabotage, the bridge circuit being briefly biased at certain intervals of time for

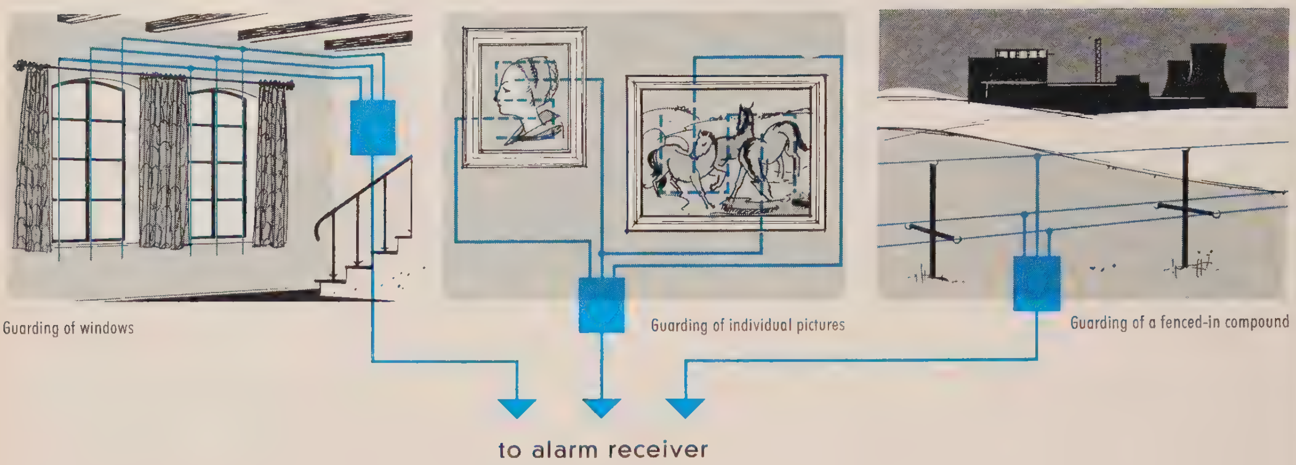


Fig. 1 Examples of the application of electromagnetic intrusion detectors

checking. This checking process calls for the use of an AND-gate circuit which prevents an alarm from being sent to the guard station in response to such bridge unbalances as are caused by the checking pulses. If the expected internal alarm criterion fails to materialize, the system is switched to the alarm condition. The result of this check shows whether the detector circuit has retained its original sensitivity.

Operating principle

Fig. 2 shows a schematic representation of the electromagnetic intrusion detection system. The monitoring electrodes a, m, b form part of a capacitive Wheatstone bridge of balanced design and represent the capacitances C_{a-m} and C_{b-m}. Any intruder approaching the electrodes will bring about a change in these capacitances. The bridge is fed by a regulated a-c source. The circuit arrangement is so designed that interference from r-f generators and atmospheric interference will be largely compensated.

When the bridge is in balance, the voltage across the bridge transformer is zero ($E_B = 0$). For continuous function monitoring of the electronic detector circuit, the capacitive bridge is biased in such a way that a voltage E_B appears across the bridge transformer. In the event of any unbalanced variations of the capacitances C_{a-m} and C_{b-m}, this voltage also varies. An unbalanced variation such as this always occurs whenever the guarded area is approached.

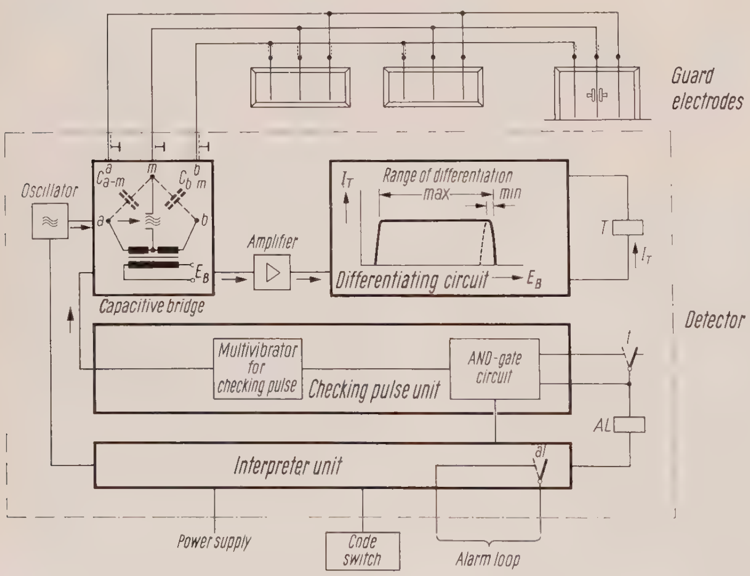


Fig. 2 Basic circuit diagram of an electromagnetic intrusion detection system

The voltage E_B is fed through a transistor amplifier to the differentiating circuit, where it is available for interpretation. In the differentiating circuit it is boosted and applied to the input of a transformer. Voltages generated across the output windings of the transformer are used to detect whether the voltage E_B exceeds or falls short of certain reference values of the operating voltage. Extremely slow variations in voltage are neutralized by the differentiating circuit. If these conditions are not met, the current I_T will fall short of its admissible value. As it acts as holding current for relay T, the latter will release and so originate an alarm.

The detector can be adapted to local conditions and safety requirements by choosing a suitable range of differentiation. The oscillator, amplifiers and detector unit of the differentiating circuit are transistorized.

The checking pulse unit embodies an astable transistor multivibrator (see Fig. 2) which imparts a bias to the capacitive bridge by means of pulses. At the same time a condition is generated in the AND-gate circuit that prevents the briefly released alarm relay *T* from becoming effective until checking operations are completed. If the checking pulse supposed to release the *T* relay briefly fails to take effect, a relay in the AND-gate circuit remains energized. At the termination of the checking period the holding circuit for relay *AL* will then be interrupted and an alarm originated. These checking pulses thus provide for regular supervision of the bridge sensitivity, the amplifiers and the sensitivity of the differentiating circuit. Any tampering with the system while it is switched off is indicated through the checking pulse unit as an alarm condition.

The power supply for the oscillator, amplifiers, differentiating circuit and checking pulse unit is regulated over a broad voltage range in order to prevent interference effects due to load variations.

Intrusion detector

The electromagnetic intrusion detection units described have been combined into a single piece of equipment, the intrusion detector, which represents the heart of any electromagnetic intrusion detection system.

The intrusion detector is accommodated in a metal case suitable for surface or flush mounting. The door of the detector is provided with a safety lock. It is also protected against drilling, and a concealed contact protects it from being forced open.

The basic unit (see Fig. 3) is mounted inside the case. It comprises the oscillator, the capacitive bridge, the amplifier unit and the relays for switching from day to night service. The differentiating circuit and checking pulse unit plug into the basic unit. If no checking pulse unit is provided, a dummy plug is inserted in its place.

To permit adaptation of the detector to various different requirements, a plug-in interpreter unit is provided, the circuitry of which determines how the detector can be assigned.

The interpreter unit interconnects the basic unit with the terminals of the outer cables. Only the electrode leads are run directly to the basic unit. The outer cables are connected by way of terminal blocks inside the case that are permanently wired to the plug connectors of the interpreter unit.

For installing an intrusion detector, the case and the electrical components are supplied in separate packages. The empty case can therefore be installed first and all the necessary cables connected up without difficulty. Then, when there is no more danger of contamination, the components may be inserted in the case.

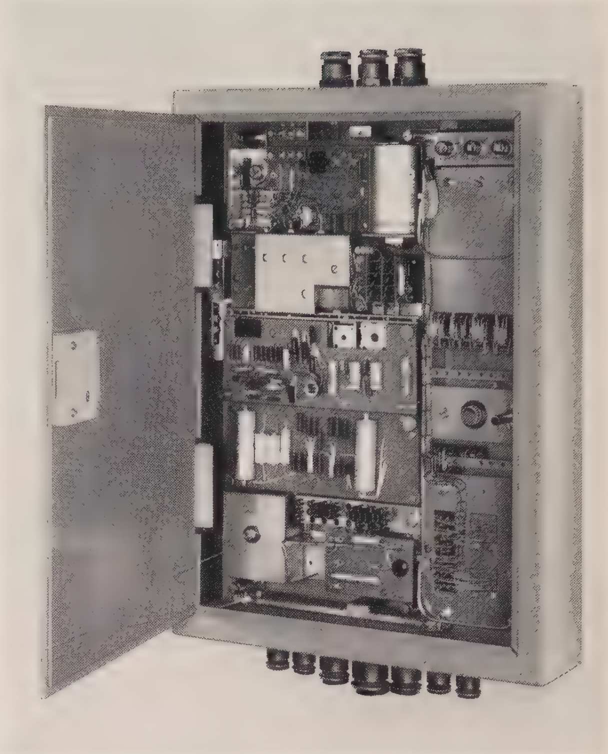


Fig. 3 Locally controlled detector

When the detector is placed in circuit, only a few trimming operations are required in order to adapt it to the capacitances of the given arrangement of electrodes.

Locally controlled detectors

Small intrusion detection systems may be provided with a locally controlled detector (Fig. 3) which operates by itself without being connected to a control center. The locally controlled detector with contact-operated alarm loop permits the connection of additional safety contacts and their resistors.

The interpreter unit is provided with illuminated push-buttons with which the detector can be switched from day service (inter-electrode capacitances ineffective) to night service (inter-electrode capacitances effective). The associated lamps indicate the selected condition.

Release of relay *AL* (see Fig. 2) originates an alarm in two different ways:

a) local alarm
(during day service; with door of case open also during night service)

b) remote alarm, e.g. to police station
(night service and door shut).

In either instance a built-in buzzer can be cut in that is silenced when the door is opened. When the door is open an alarm lamp in the interpreter unit lights up. The alarm can be canceled by actuating a button. The interpreter

unit also embodies a charging and battery monitoring feature for monitoring the external power supply. Power outages are indicated by the built-in buzzer or, when the door is open, by lamps. Unassigned contacts are available for additional alarm and fault indications. Locally controlled detectors are able to interoperate with an external code switch, the secret code of which can be selected by the guard with a rotary switch. If a wrong code is selected, an alarm is originated after a predetermined period so as to indicate tampering.

Centrally controlled and centrally monitored intrusion detectors

Large intrusion detection systems requiring a great many detectors are provided with centrally controlled or centrally monitored detectors. These detectors are connected with central stations at which they are monitored, and, if necessary, controlled.

The interpreter unit of a centrally controlled detector is provided with relays for remote switching from day to night service, and an access relay for checking the bridge voltage.

The interpreter unit of a centrally monitored detector, on the other hand, is not provided with a day/night switching circuit.

The monitoring devices for the alarm loops of centrally controlled and centrally monitored detectors are installed at a central station. The door contacts of such detectors are inserted in the alarm loop so that an alarm will be originated whenever the door of the case is opened.

If a detector without a checking pulse unit is installed, the detector circuit is checked each time the detector is switched from day to night service.

Application

The instruction detector is suitable for guarding rooms, entrances and valuable objects inside or outside buildings. Rooms, entrances (windows, doors, etc.), objects or compounds are fitted with suitable electrodes that are connected with the detector by way of low-capacitance cables. It is further possible to insulate metallic objects (safes, filing cabinets, etc.) so that they themselves act as an electrode in conjunction with an auxiliary electrode. Pictures can likewise be guarded against human approach or being taken down.

The range of application of detectors is extremely wide and can be further extended at any time to solve a great many practical problems.

Electrical Equipment for Induction Heating

By Wilhelm Mosch

Induction heating has found steadily increasing application in recent years. The power required for this varies widely. It is of the order of 1 to 200 kW for high-frequency equipment and rises to several 1,000 kW for mains-frequency and medium-frequency plants.

Fig. 1 shows a mains-frequency induction heating plant for billets, which was put into operation last year by the Siemens-Schuckertwerke. The plant has a connected load of about 1,500 kVA. It is used for reheating light-metal billets 900 mm long and 350 mm in diameter to a temperature of 540 °C. The output is 3.5 tonnes/hr.

Operation of the plant is largely automatic. The electrical equipment is designed to enable any desired temperature increase to be set during the heating process.

If a conductive charge is inserted in a coil through which an alternating current is flowing, secondary currents are induced in it which cause a rise in temperature. As a function of the power P and the heating time t, the charge can be heated by the required temperature rise ΔT:

$$\Delta T = \frac{P\,t}{c\,M}$$

where c is the specific heat of the material and
M is the mass of the material to be heated.

By this method, temperatures up to about 2,500 °C can be attained. The field of application ranges from drying and hot working to melting and sintering.

As the induced current directly heats the lateral surface zone of the charge, the heat cycles are considerably shorter than with indirect heating. In addition, one can arrange for heating to take place only where it is required (partial heating). The induced current drops within the charge with the radial distance x from the surface according to the equation

$$I_x = I_0\, e^{-x/\delta}$$

where I_0 is the current on the surface of the charge.
δ designates the depth of current penetration at which the current has fallen to the value e^{-1}. The depth of penetration decreases as the frequency rises. This process is economical if the diameter of the charge is at least 3.5 δ. Table 1 shows the frequencies used for induction heating.

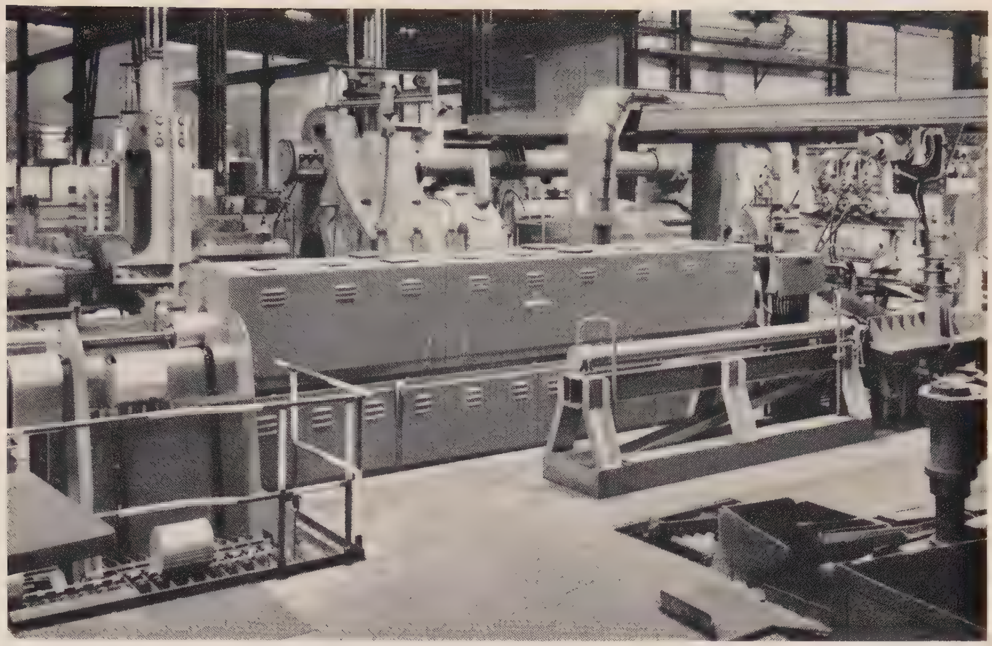


Fig. 1 50-c/s low-frequency installation for induction heating of billets

As the inductance of the coil around the charge is very high compared with its resistance, the power factor of induction coils in mains-frequency and medium-frequency installations is corrected to approximately unity by means of capacitors. The transformers, medium-frequency generators, switchgear and leads need largely only be designed for the active power component. In the case of high-frequency valve oscillators, these capacitors constitute part of the oscillatory circuit and are built into the oscillators.

In mains-frequency installations, the load is connected to the existing power system either single-phase or three-phase. In many cases, the load imposed by the single-phase induction coil is balanced on the three phases by means of a reactor and capacitors.

For small-size plants, the transformers and p.f.-correction capacitors can be dispensed with. The plant is designed as with normal power systems.

For medium-frequency plants, normal equipment as used in conventional power installations is preferred, while the motor-generator sets and capacitors must be specially designed for the particular frequency. The electrical part of such an installation comprises motor-generator set, switchgear and capacitor bank (Fig. 2).

The motor-generator sets generally consist of a single-phase generator and an induction motor. As the number of poles of the generator, at a given speed, rises proportionately to the frequency, medium-frequency generators cannot be built in the form of orthodox salient-pole machines owing to the small space available for the field winding. Up to about 1 kc/s, it is still possible to use heteropolar generators. A slotted rotor is used instead of a magnet wheel with built-on salient poles; the teeth of the rotor form the poles, while the field winding is placed in the slots. Fig. 3 shows a 500-c/s, 3,000-kVA generator in two-bearing design.

Generators for producing frequencies above 1 kc/s operate in principle with a fluctuating unidirectional field.

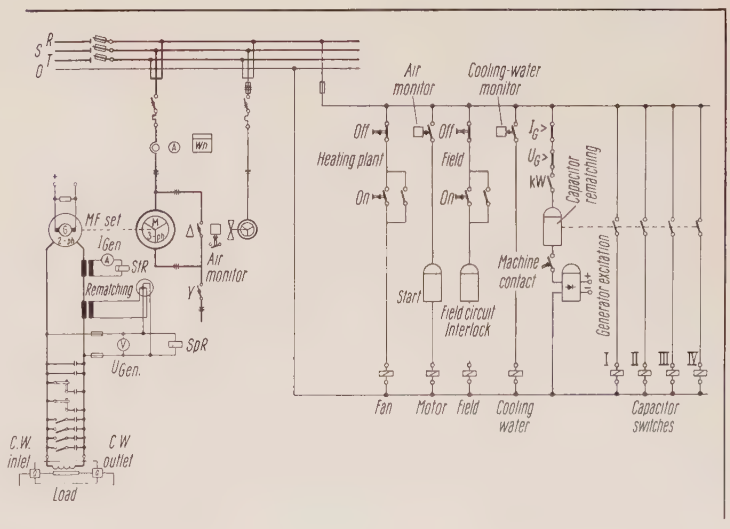


Fig. 2 Basic circuit of a medium-frequency plant for induction heating

Power source	Power system	Motor-generator sets				Valve oscillators		
Designation	Mains frequency	Medium frequency				High frequency		
Frequency c/s	50 (40 to 60)	500	2,000	4,000	10,000	1×10^5 to 5×10^6		
kW per unit	10 to 2,000	100 to 3,000	30 to 600	30 to 200	10 to 200	1 to 5	5 to 50	100 to 200
Max. inducible heat density kW/cm²	0.1	0.25	0.6	0.8	2	10 to 30		
Depth of current penetration in steel at 1,000 °C (μ 1) mm	70	23	11	8	5	2 to 0.3		
Melting and sintering	1 t <	In air or in a vacuum less than 10^{-4} Torr 10 t >	Weight of charge	> 1 kg		< 1 kg		
			in a vacuum better than 10^{-4} Torr					
Welding			Tubes, inductively					
Hardening		1,000> 30>	Dimensions in mm Tempering depth in mm		> 10 > 2	< 60 < 3 to 0.3		
Soldering	Soft and hard soldering with copper, silver and special solders Large and small surfaces					Small and thin parts		
Tempering		Large parts				Small parts (wire)		
Mass heating Steel and iron	150 <	In forging, pressing and rolling mills 200 >	Dia. of charge in mm		14	< 15		
Metals	50–100 <	250 >	Dia. of charge in mm		> 4 to 8	> 0.5 to 1		
Annealing	To induce softness, remove stresses and refine the crystalline structure Large parts, e.g. seams on tubes					(600 to 800 °C) Small parts		
Heating to about 300 °C	Shrinking, heating of pipelines, boilers, containers		e.g. drying of welding electrodes, heating of strips, plates, etc.					

Table 1 Frequencies used for induction heating

This is achieved by changing the permeance of the air gap through the teeth of an inductor in the rhythm of the frequency required, thus modulating the unidirectional flux. To produce the medium-frequency voltage, the first of the harmonics thus obtained is used. Machines operating on this principle are the Lorenz generator with oblong field coils, the homopolar generator with ring-shaped field coil, and the GUY generator, in which rotor and stator are toothed for producing very high frequencies. For the generator stator, high-alloy sheets with a particularly low eddy-current loss are used. Medium-frequency capacitors are designed to have a high power density, and are accordingly very small. The heat losses are dissipated through additional cooling arrangements (air-blast or liquid cooling), or reduced to a minimum by using a low-loss dielectric.

The switchgear comprises the equipment required for starting, supervision and control and, if necessary, also

for regulating the plant. In small installations, all the switchgear and capacitors are housed in a cubicle. As the power factor of the load circuit changes with the temperature and the dimensions of the charge, additional control gear is provided to rematch the capacitor bank to the work.

Large switching stations are constructed to suit the local conditions; the capacitor bank is in this case set up in a separate room.

When laying the cables, it should be seen to it that the inductance of the leads, particularly those to the capacitors, is at a minimum.

Fig. 3 500-c/s, 3,000-kVA motor-generator set on the test bed

The induction heater or work handling equipment is designed to suit the particular job; it moves the charge to be heated through the induction coil, the shape of which is designed for maximum efficiency. In almost all cases, these coils consist of copper tubing, through which the cooling water flows. The rate of feed, or the working cycle, are adapted to the working rhythm of the production line or forging press.

Plants for induction heating have found increasing application in the last few years. They are used with success in many manufacturing plants, and have contributed generally to improving the working process and the quality of the material.

Substation Transformers Suitable for the Direct Connection of Cables

By Hermann Adolph

In transformer stations, high- and low-voltage cables must frequently be connected direct to the transformers, particularly where these are installed in the open. The connection of the cables to the transformer must offer not only sufficient electrical and mechanical reliability in operation, but also adequate protection against contact and contamination of the live parts. It must be capable of standing up to all weather conditions. Moreover, it must be possible to detach the cables from the transformer in a simple manner without damaging or destroying their prepared ends.

Siemens-Schuckertwerke have developed oil- or Clophen-filled distribution transformers which meet these requirements.

Transformers with terminal cover

Up to insulation rating 10 kV, terminal covers (see Fig. 1) are a particularly practical and technically and economically favourable solution. The covers are made in two parts. The lower part, which is welded to the cover plate of the transformer tank, carries the entry glands. The detachable upper part is sealed against the lower part, and can easily be pulled off upwards. The terminal bushings are then exposed, so that plenty of space is available for fitting the cables.

The cable entry glands are likewise split. Their lower sections are welded to the lower part of the terminal cover. The upper section of the glands can be taken off after removing some screws and enable the cables to be laid in the glands with ease. This design obviates the cables having to be "threaded" through, with the advantage that no cable work has to be done when the transformer is exchanged. Clips relieve the cable cores from strain.

It will generally be possible to make connection on the high-voltage side with a single cable. In the rare cases where two cables are necessary, the stepped conductor ends, from which the insulation has been stripped, can be phased out without difficulty and connected at the terminals.

For the outgoing circuit on the low-voltage side of the transformer, on the other hand, several cables will frequently be required. Depending on the rating, up to five low-voltage glands can be mounted on the terminal cover. An auxiliary busbar system enables the various

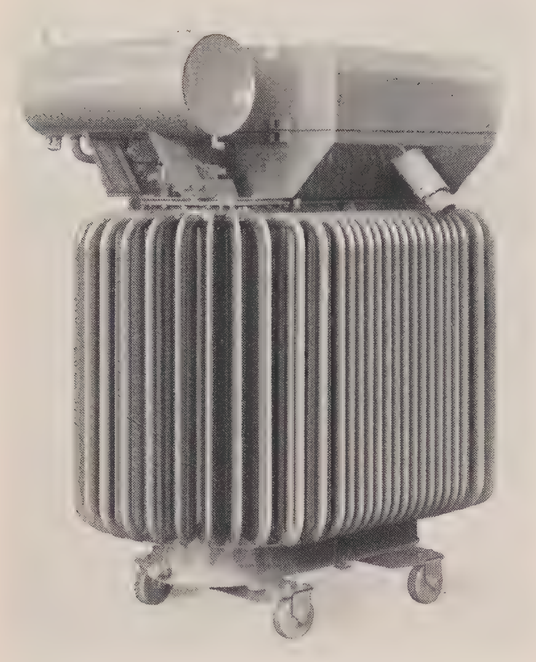


Fig. 1 Transformer with terminal cover

cables to be simply mounted side by side, even where a large number is involved.

The breather glands provided are intended to prevent the formation of condensation in the terminal cover. This

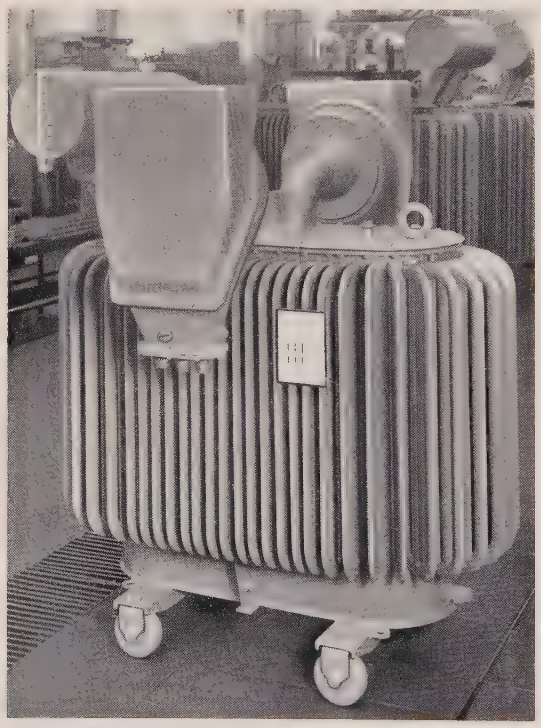


Fig. 2 Transformer with compound-filled cable boxes

provides transformers with terminal covers of enclosure P 42 (protection against contact with tools and other implements of all kinds and harmful dust deposits in the interior, protection against splashing water falling vertically or inclined down to 30° above the horizontal). The inside of the cover, like the outside of the transformer, is finished with three coats of corrosion-proof paint. Thermometer wells and Buchholz protection are arranged outside the terminal cover, and are readily accessible. The operating mechanism for the tap changer, on the other hand, is under the terminal cover.

From a manufacturing point of view, transformers with terminal covers have the advantage that standard components – above all standard bushings – can generally be used. Moreover, the interior of the cover need not be filled either with oil or compound.

The terminal cover can be designed for the connection both of compound-impregnated cables with metal sheath and of plastic-insulated cables of all kinds. Where necessary, the cable cores are provided with sealing ends, as is customary in switchgear installations where cables are run in air.

Transformers with compound-filled cable boxes

In practice, terminal covers can only be used on transformers with an insulation rating of up to 10 kV. For higher voltage ratings (20 kV, 30 kV), the distances between terminals and to earth, as well as the length of the cable cores in air from which the insulation is stripped, as laid down in the applicable VDE specifications, require so much space that compound-filled cable boxes have markedly smaller dimensions and are also generally more economical than terminal covers. Moreover, the insulation of cable ends above 10 kV calls for materials with dielectric properties greatly superior to air, which are obtained in any case when normal compounds are used. Furthermore, compound-filled cable boxes are frequently required in special cases also for low-voltage circuits, e.g. in the tropics.

Compound-filled cable boxes (see Fig. 2) must likewise meet the requirements for electrical and mechanical strength, protection against contact, contamination and weather, the possibility of disconnecting the cables from the transformer without damaging the prepared cable ends, and of connecting all types of cables. The type of enclosure is P 44 according to DIN 40050.

The cable boxes are flanged to pipe bends on the cover plate of the transformer tank. A plate of insulating material is inserted oil-tight in the pipe bends, so that the insulating liquid of the transformer cannot come into contact with the cable sealing compound. The insulating plate also carries the transformer bushings; normally, three terminals for 200 A are fitted on the high-voltage side, and 4 terminals for 630 A on the low-voltage side

(Fig. 3). For currents in excess of 630 A, further pipe bends and cable boxes must be provided.

The cable box is split. The lower part is screwed oil-tight to the pipe bend of the transformer. A large cover

Fig. 3 Arrangement of the high-voltage terminals (left) and of the low-voltage terminals (right) on transformers with compound-filled cable boxes

is tightly connected to the lower part by means of oblique flanges. It is designed to provide sufficient space for installing the cables. The compound covers the gasket of the flanges under all operating conditions, and thus prevents the leaking in of air. Moreover, a sufficiently large expansion space at the top is provided for the varying thermal expansion of the compound obtaining in operation. To prevent corona discharge, the expansion space is screened by a perforated potential control plate arranged below the lowest oil level. The filling, draining and earthing screws are readily accessible. The filling screw has a rod for checking the level of the compound. The cable box is sealed off at the bottom by a gland plate. Depending on the type of cable used – belted cable, three-core S.L. cable, plastic-insulated cable, etc. – suitable entry glands must be provided for insertion at the place of installation. The gland plate can take 2 three- or four-core cables, or 3 single-core cables.

Special terminals are fitted for connecting the cable cores to the bushing studs. They enable the bare conductor ends of the cables to be easily inserted in the terminals without the use of cable lugs.

Thermometer wells, Buchholz protection and the operating mechanism of the tap changer are readily accessible. The oil-level indicator on the oil conservator can be easily read.

NEW EQUIPMENT

Construction of Nationwide Telex Network with Long-Distance Dialing in Indonesia

By Friedhold Strässer

In Indonesia, as in other countries, the steady growth of communications and of commerce has given rise to a demand for a telex network. Indonesia has in fact become the first country in all Asia – including the Pacific archipelagos – to decide to construct a public teleprinter network (telex) for nationwide dialing and operation over shortwave radio, radio links, open-wire lines and cable. This decision is all the more remarkable in that the telex network will be one of the first to permit direct dialing by patrons over radio channels. The vast teleprinter network now under construction was the subject of an agreement concluded some 2 $^1/_2$ years ago in Djakarta between the Indonesian Government and Siemens & Halske.

The network serves for intercommunication between the principal commercial, industrial and administrational centers of the islands of Java, Sumatra, Borneo and Celebes. The heart of the network is on Java, with its fully interconnected area switching centers of Djakarta, Bandung, Semarang and Surabaja. Traffic between the area centers on Java is carried primarily by open-wire lines, but radio link systems and cables are also used. On account of its location and important commercial status, Djakarta is at present accorded priority over the other area centers with respect to the connection of main telex centers and sub-centers. Thus all telex centers that can be reached by shortwave radio and radio links are at present connected to Djakarta. Provision has been made for the connection of further district centers and sub-centers to the other area centers (Bandung, Semarang and Surabaja). Fig. 1 shows the configuration of the network, which so far comprises 19 teleprinter switching centers with a total of 500 patrons. Siemens & Halske are also supplying the transmission systems for the lines interconnecting the centers. Each of these lines accommodates between 3 and 14 teleprinter channels.

Indonesian telex patrons dial wanted numbers in cities and towns the same as with all other telex networks adapted for dial operation. Patron stations are for this purpose equipped with conventional dial facilities. New patrons are primarily allocated the Siemens model 100 pageprinter.

The switching centers all operate on the well-proven Siemens TW 39 system and are distributed among the principal islands of Indonesia. The forerunners of the network now in construction

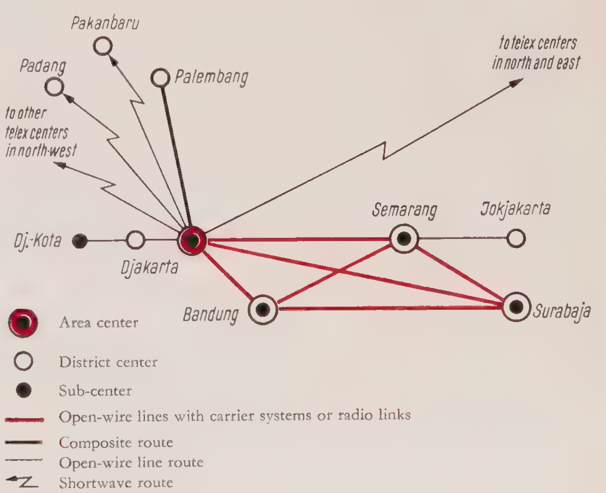


Fig. 1 Area center with district center section

Fig. 2 PTT building in Bandung, the site of installation of the first TW 39 teleprinter switching center supplied by Siemens & Halske

were two small TW 39 switching centers in Bandung (Fig. 2) and Djakarta which were originally supplied to the Indonesian PTT for experimental purposes and subsequently assigned to the telex network.

The geographical structure of Indonesia presents the planners of a communications network with a number of extremely interesting problems. Special measures had to be adopted with respect to the transmitting media for the connecting paths between the switching centers. Links that run from island to island and whose switching centers are located between 625 and 1,250 miles apart operate over shortwave channels. Where telex links are required for interconnecting commercial centers, they have been combined with existing long-haul transmission equipment for telephony.

For linking up all the switching centers located outside of Java, which are connected radially to the Djakarta area center, Siemens & Halske have supplied type WTK-V shortwave radiotelegraph systems. With these systems it is possible to accommodate three two-tone teleprinter channels in a single speech band.

The WTK-V system is suitable both for the transmission of 5-unit code teleprinter signals and, in certain circumstances, TW 39 dial pulses.

The inter-office telephone trunks on Java operate for the most part with Z3F, Z12F and VZ12 long-line carrier systems, each having from 3 to 12 telephone channels. The telex circuits are taken to WTS-24 carrier telegraph systems, which permit the establishment of up to 24 telex channels per telephone channel. One or two circuits of these systems are usually sufficient to permit establishment of the required quantity of telex channels.

The link between Djakarta and Palembang differs from the others in that it runs through several different transmitting systems. Part of the route is composed of open-wire lines, whereas a radio link is used to span the Sunda Straits. On account of the large size of the linegroups already required for telephone traffic, recourse had here to be taken to the Siemens FM 120/300 over-horizon radio system, which operates with up to 120 telephone channels. The radio frequencies lie in the 300-mc range. Propagation at these

Fig. 3 Indonesian PTT personnel place a teleprinter switching center in service. In the photograph the line current is being adjusted for the various telex patrons

wavelengths is particularly favorable in this given case. Here, too, only one of the telephone channels had to be sacrificed to obtain the telex channels.

Construction work on the telex network has now been completed (Fig. 3). Indonesian engineers and fitters are being trained at Siemens factories in Germany and by German specialists in Indonesia in the handling and maintenance of the equipment. Through this liberally conceived project the Indonesian Government has smoothed the way for industry, commerce and the civil services to continue the economic development of the islands.

EMD Dial Offices for Korea

By Wolfgang Tietz

In March 1959 the government of South Korea placed an order with Siemens & Halske for five EMD dial offices with a total of 15,000 line units. In the summer of 1959 this order was increased by 4800 line units. A further order for 30,000 line units followed in October 1960. A total of eight EMD dial offices with 49,800 line units are at present under construction in five cities (Fig. 1); the capital of Seoul has been assigned 25,800 line units.

Korean engineers and technicians have attended theoretical and practical training courses in Korea and Germany where they have been familiarized with telephone engineering and, in particular, with the EMD technique (Fig. 2). As a result it is now possible for all construction work to be carried out by members of the Korean PTT supported by German construction personnel (Fig. 3).

The new dial offices of the Seoul local network interoperate with several Strowger dial offices and a U.S. long-distance office (Fig. 4). This ready ability to interoperate with dial offices equipped with switches of other make is a typical feature of the EMD-M system, which operates with markers but at the same time offers all the well-known advantages of the Siemens system such as great flexibility with respect to numbering, length of call numbers, quantity of subscribers, and traffic intensity [1].

The EMD switches of the EMD-M system are marked by control sets [2, 3]. Each frame is assigned two or three control sets, which are taken into use only for the short period that a switch requires to operate. Switching devices required for the entire duration of a call are the pulse controllers, connector circuits and, where necessary, the pulse controllers for incoming selectors assigned to each connecting path. The pulse controller is equipped with a mechanical dial pulse repeater [4] which, being designed as a buffer storage, can process call numbers of any length. The insertion of a dial pulse repeater in the connecting path secures independence from inter-digit pauses; liberal tolerances are allowed for the return speed and pulse ratio of the dial; pulse distortion due to inferior subscriber lines does not affect the operation of the system. The system operates on 48 v.

Fig. 1 Orders awarded to Siemens & Halske cover the supply of EMD dial offices with a total of 49,800 line units (LU) for five towns in Korea

Fig. 2 Members of the PTT in Seoul attending a training course in telephone engineering

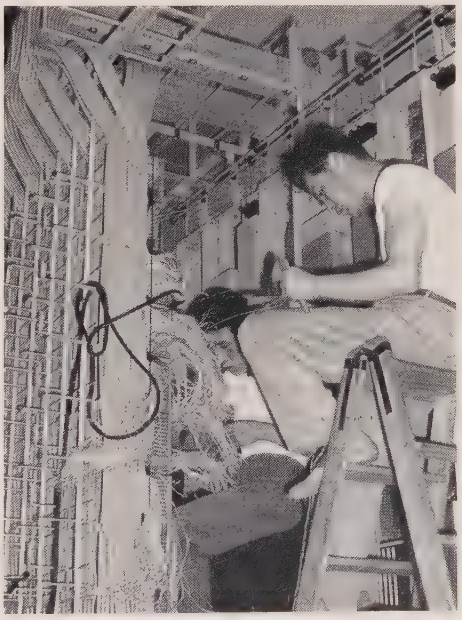


Fig. 3 Wiring work on a TDF for the flexible cross-connection of line connector outlets and subscriber line circuit/linefinder inlets

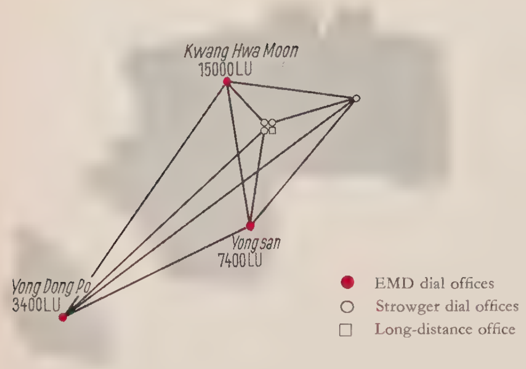


Fig. 4 Location of dial offices in Seoul local network

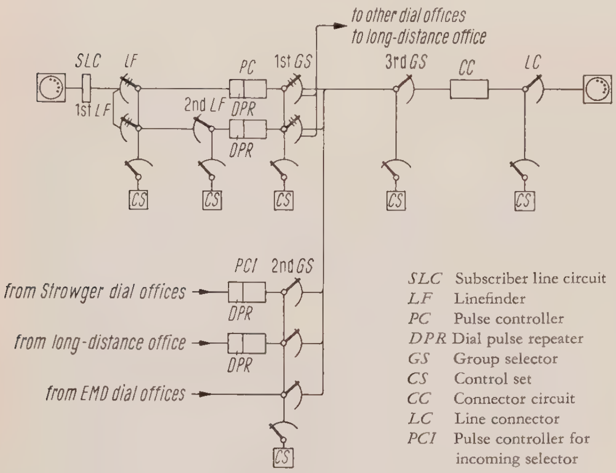


Fig. 5 Trunking scheme in EMD-M system

Operating principle of switching stages

Fig. 5 shows the basic trunking scheme. 200-line groups with 200-pt linefinders (*LF's*) and 1st *LF's*, and 100-pt 2nd *LF's* have been formed in the linefinder stage for the basic traffic intensity of 9.3 erl per 100 subscribers. The *LF's* offer the basic traffic directly to the 1st group selectors (*GS*); the peak traffic overflows to the 1st *LF's*. The overflow traffic loads of several subscriber groups are merged by the 2nd *LF's* and then likewise offered to the 1st *GS's*. This arrangement secures improved occupancy for the 1st *GS's* and the pulse controllers.

Each 1st *GS* in the group selector stage is assigned a pulse controller for receiving, storing and retransmitting dial pulses, feeding and transmitting audible tones to the calling telephone, and metering. Through the use of 220-pt 1st *GS's* it is possible to evaluate a further digit following a certain digit and in this way to discriminate among a total of 19 routes, thereby saving one *GS* stage. The 2nd to 4th *GS* stages are assigned 110-pt switches. As the outlets to the routes can be allocated at option, any accessibility can be chosen.

The pulse controllers for incoming selectors, as also their dial pulse repeaters, permit the EMD-M system to be connected to dial offices equipped with switches of other make and are used for switch control along with the control sets.

In the line connector stage, each line connector (*LC*) is assigned a connector circuit for ringing and feeding the wanted number, transmitting audible tones, and initiating metering. Up to 100 subscriber lines can be assigned to each *LC* group.

Bibliography

[1] Laas, K. and Meigel, H.: EMD Dial Offices Inaugurated in USA. Siemens Review XXVI (1959) pp. 1 to 5

[2] Töpfer, H. and Laas, K.: A Local EMD System Using Individual Buffer Storages. Siemens Review XXV (1958) pp. 182 to 185

[3] Töpfer, H. and Brandstetter, A.: The EMD Switch in Dial Offices. Siemens Review XXVII (1960) pp. 185 to 188

[4] Franzen, J.-F. and Vogel, H.: Siemens Dial Pulse Repeater. Siemens Review XXV (1958) pp. 238 to 241

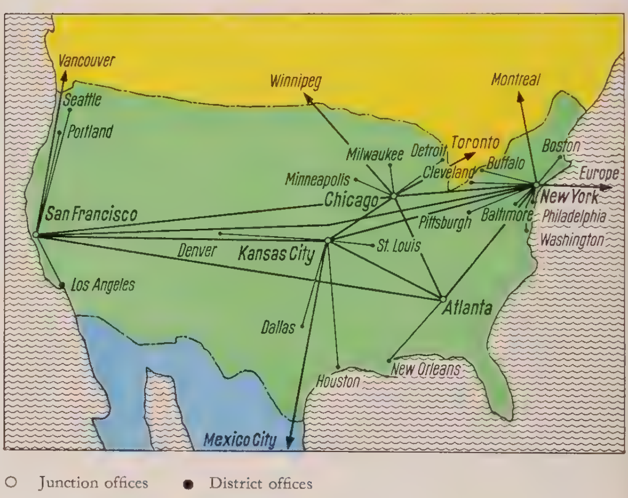
Western Union's Telex Network

By Hans Dobermann

Rapid progress is being made in the installation of the North American telex network operated by The Western Union Telegraph Company. The network configuration has already been described elsewhere [1, 2]. Numerous new switching centers have been placed in service in recent months.

The basic network with its junction offices in New York, Chicago, San Francisco, Kansas City, Atlanta and a district office in Los Angeles began operation in early May this year. Our TWM 2 system is used in the network of the junction offices, to which 17 district offices have already been connected. Operation has been troublefree from the beginning. The switching centers already in use are to be expanded and new switching centers placed in service during the present year. The number of subscribers is at present about 1,000 and will increase to over 10,000 as the network expands. Between 30,000 and 50,000 subscribers are expected to be secured over the course of a few years.

The network plan shows the switching centers that are already in operation.



Present extension of Western Union's telex network

Bibliography

[1] Easterlin, Ph. R. and Rossberg, E. A.: Telex in North America. Siemens Review XXVII (1960) pp. 281 to 285

[2] Rädler, H.: The Model-TWM 2 Automatic Teleprinter Switching System for the Western Union Telegraph Company. Siemens Review XXVII (1960) pp. 286 to 290

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Wolfgang Liebe and Winfried Boldin

Calorimetric Methods of Determining the Efficiency of Large Machines

4½ pages, 10 figures, bibliography

Siemens Review XXVIII (1961) pp. 319 to 323

Practical experience gained on machines and in tests on models has shown that the calorimetric method can be successfully applied to the determination of the losses and efficiency of large waterwheel generators. Provided adequate care is taken, calorimetric measurements yield reliable results and are even superior to the conventional methods in that the windage losses can be determined with a high degree of accuracy. Calorimetric measurements can be carried out both in the air circuit and in the water circuit, the method to which preference is given depending on the local conditions.

SIEMENS U.D.C. 621.375:621.395.001.6

Heinrich Nottebrock †

Fifty Years of Siemens Amplifier Technology

5½ pages, 7 figures, bibliography

Siemens Review XXVIII (1961) pp. 324 to 329

First amplifiers operating with a mechanically controlled Brown relay (1910) are considered. The section on amplifiers operating with electrons controlled in an ion chamber is followed by reference to the Lieben tube. The section on amplifiers operating with electrons controlled in a vacuum describes the development of high-vacuum hot-cathode tubes for various applications. In conclusion, reference is also made to amplifiers with a controlled magnetic flux, amplifiers with electrons controlled in a semiconductor, and, with a view to future development work, special-purpose amplifiers. Siemens & Halske's substantial contribution to the development of amplifier technology is pointed up.

SIEMENS U.D.C. 531.753:531.781.2

Hubert Burster

Circuit Arrangements for Strain-gauge Load-cell Weighing Installations

4 pages, 5 figures

Siemens Review XXVIII (1961) pp. 329 to 333

Automation requires the use of balances in the whole course of production. Because of the robust construction of their load cells, electrical balances have proved particularly suited for this purpose. An essential element of a circuit with strain-gauge load cells is an analog self-balancing potentiometer which derives its voltage, in the same way as the load cells, from a simple power supply unit with two unstabilized outputs not galvanically connected with each other. This circuit combines the advantages of both voltage compensation and independence of mains-voltage fluctuations. The influence of the line length is eliminated for distances of up to 1,000 metres (3,300 ft.). The tolerance for the complete installation, consisting of a series of self-contained units, is within 0.3% of full scale value.

SIEMENS U.D.C. 621.395.3

Konrad Rohde

3 Million EMD Telephone Terminals

2 pages, 1 figure, bibliography

Siemens Review XXVIII (1961) pp. 336 to 338

The success of the EMD technique is based on its operating reliability and flexibility. The flexibility of dial systems is of major importance for the future development of telephone networks. The principal relevant factors and their influence of the future development of telephone networks are treated.

SIEMENS U.D.C. 621.314.241:621.384.612.1

Hans Gerhard Berger and Helmut Watzinger

Motor-Generator Sets with Precision Current Control for Feeding Focusing Electromagnets

3 pages, 4 figures

Siemens Review XXVIII (1961) pp. 333 to 336

For feeding focusing electromagnets, located in accelerators between the acceleration orbit and the test unit, motor-generator sets with current control to an accuracy of the order of 0.1 percent are used. The article describes an m.g. plant erected in Geneva (CERN). The magnet excitation currents must be kept constant in the range between 10 and 100 percent. The control consists of a combination of a high-speed transistorized two-step controller with a highly-sensitive snap-action magnetic amplifier.

SIEMENS U.D.C. 621.316.3.027.26

Herbert Lausmann and Josef Schmitt

Distribution Centre N 1960 – a Flexible Low-voltage Metal-clad Distribution Board with Drawout Units

3 pages, 3 figures

Siemens Review XXVIII (1961) pp. 338 to 341

The distribution board N 1960 is a further development of low-voltage metal-clad boards and can, for instance, be installed at the load centres in factory workshops. The new built-in units have a testing and an off position. The flexibility of the new design permits various large equipment units to be interchanged.

SIEMENS U.D.C. 645.924.3

Sven Wirén

Intrusion Detection by Electromagnetic Fields

3 pages, 3 figures

Siemens Review XXVIII (1961) pp. 341 to 344

The effective protection of a room or compound from unauthorized entry is secured by burglar alarm systems in which an alarm unit operates as soon as the protected area is approached. This is accomplished through the use of electrical assemblies whose capacitances with respect to each other and to ground are monitored by a special circuit.
The influence of extremely slow variations in capacitance such as may occur due to the effects of the weather is suppressed by a differential arrangement. The response sensitivity of the overall monitoring circuit is automatically checked at regular intervals. A description of the operating principle and layout of the equipment is followed by an account of further typical applications.

SIEMENS U.D.C. 621.365.5

Wilhelm Mosch

Electrical Equipment for Induction Heating

3 pages, 3 figures, 1 table

Siemens Review XXVIII (1961) pp. 344 to 347

In the course of recent years induction heating has gained considerably in significance. Such equipment is used mainly for soldering, hardening and heating for hot-working and smelting. Depending on the particular requirements, industrial-frequency, medium-frequency or high-frequency equipment is used. These equipments have the following advantages over indirectly heated furnaces: Shorter heating times, less workpiece burning and simpler adjustment.
A description is given of the electrical equipment for such induction heaters.

For cutting out and pasting on index cards

SIEMENS U.D.C. 621.314.21

HERMANN ADOLPH

Substation Transformers Suitable for the Direct Connection of Cables

2 pages, 3 figures

Siemens Review XXVIII (1961) pp. 347 to 349

It often becomes necessary to connect cables direct to transformers.
Details are given of transformers to which cables can easily be fitted and which are also fully protected against contact, contamination and adverse weather conditions.

SIEMENS U.D.C. 621.394.74(91)

FRIEDHOLD STRÄSSER

Construction of Nationwide Telex Network with Long-Distance Dialing in Indonesia

1½ pages, 3 figures

Siemens Review XXVIII (1961) pp. 349 to 351

The focal point of the nationwide network in construction in Indonesia is the island of Java. Among the regional offices on Java, priority is assigned to Djakarta on account of its superior economic importance as compared with Bandung, Semarang and Surabaya. All Indonesian telex offices that can be reached over shortwave and radio links are also directly linked with Djakarta. The telex network here described at present serves a total of 19 teleprinter switching centers with 500 patrons.

SIEMENS U.D.C. 621.395.34(519)

WOLFGANG TIETZ

EMD Dial Offices for Korea

1½ pages, 5 figures, bibliography

Siemens Review XXVIII (1961) pp. 351 and 352

The government of South Korea has awarded Siemens & Halske orders covering dial offices for 49,800 subscriber line units operating on the EMD system M.

SIEMENS U.D.C. 621.394.74 (73)

HANS DOBERMANN

Western Union's Telex Network

½ page, 1 figure, bibliography

Siemens Review XXVIII (1961) p. 352

A progress report is given on the construction of Western Union's telex network. Its future expansion is outlined.

SIEMENS